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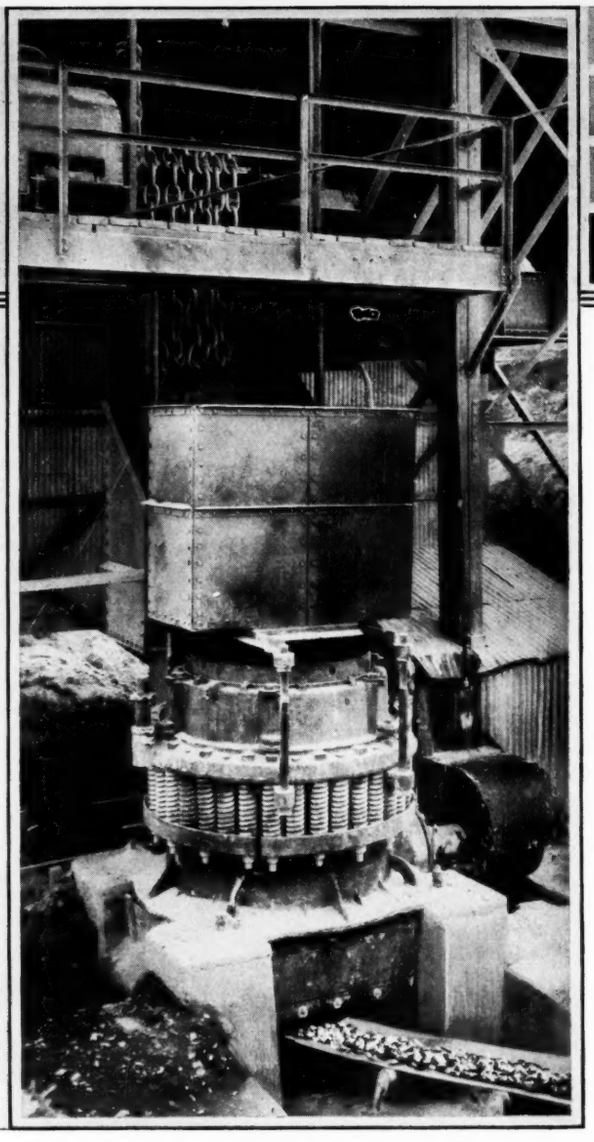

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Engineering & Mining World

A. W. ALLEN, *Editor*

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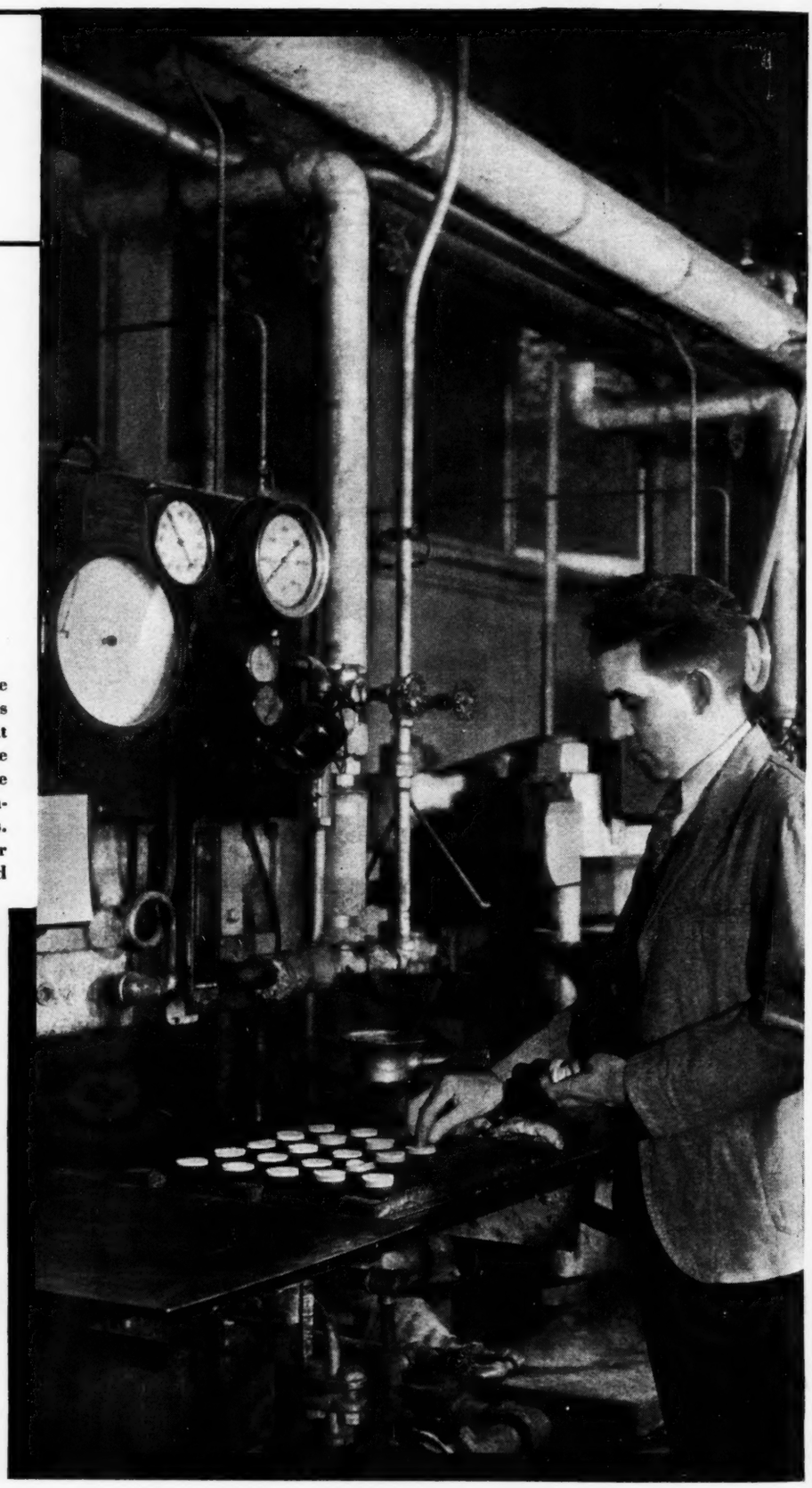

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May, 1932 Vol. 133—No. 5

A. W. ALLEN, *Editor*

Research Stimulates Non-Metallic Industries

A SIGNIFICANT CONTRIBUTION to the utilization of non-metallic mineral products has been made by the Vitrefrax Corporation, of Los Angeles, which has built a large business around a research department headed by Mr. T. S. Curtis, an accomplished ceramic engineer. At first it pioneered in high-grade refractories, utilizing magnesium oxide for periclase and aluminum silicates for synthesized material used in refractory brick of various types. Intensive prospecting disclosed suitable minerals, including a cyanite found near Ogilby, Calif., from which several processed refractory and ceramic compounds were developed as research suggested appropriate electric-furnace technique. A specialized demand was met, and a business established.

Research along other lines was also undertaken, principally in the development of a ceramic body suitable for white wares. The objectives, established by a careful study of the industry, included the production of a stronger product, a saving in weight, and a reduction in the proportion of reject finished ware. A synthetic body was evolved that met the primary objectives. Next, a search was made to find a natural material containing the clay, feldspar, and quartz elements in approximately correct proportions and in a physical state that would insure a standardized commercial product at a cost permitting shipment to eastern markets. Prolonged search resulted in the finding of a plastic trachyte, with characteristics that met requirements.

The new ceramic body was given the name of vitrolon, and a special unit for its preparation was erected at the company's Vernon plant, including a standard vitrolon-lined tube mill, served by automatic feeder. Flint pebbles are used for grinding in water, the slurry being passed over a vibrating screen and the oversize pumped back to the tube-mill circuit. Three products are made—120, 150, and 200 mesh. Each pulp is pumped, past a magnetic separator, into one of three tanks lined with vitrolon bricks. From these the slurry is pumped to a filter press, for the removal of excess water. Each batch is analyzed, and the filter cakes are then dried and stockpiled, sacked in the three sizes ready for marketing. Great care is taken to insure freedom from contamination at all points in the process. The product is shipped in box cars as far east as Indiana, and via Panama to Atlantic points. Quality of product and low cost are such that manufacturers of dinner ware find the use of this standardized ceramic base highly advantageous.

This successful outcome of persistent research began by an analysis of the failure of dinner-ware manufacturers to hold their markets in the face of competition from outside the United States. A product superior or equal to the foreign ware was necessary, and the cost of production had to be such that a competitive advantage would prevail. Suitable raw materials at low cost were essential. Ordinary manufacture involved use of flint, spar, and clay; but the physical and chemical variations were such as to complicate processing and result in a product of uncertain quality and strength. Mr. Curtis concentrated research on an exact standardization of a body material that could be depended upon to give consistent results. He succeeded. The new material is used in the manufacture of table ware and high-quality tile, in connection with which the problem of warpage has been overcome.

The Vitrefrax Corporation is using, for the manufacture of its products, about 27 non-metallic minerals, most of which must meet exacting specifications. For this reason, extensive prospecting and careful examination of available materials are necessary. As an example, trachyte is a not uncommon type of igneous rock, but plastic trachyte is rare, and a trachyte having the plasticity and the other chemical and physical characteristics needed is still rarer. The deposit found is therefore of importance.

The work of Mr. Curtis and the Vitrefrax Corporation illustrates a successful method of exploiting non-metallic minerals. The producer of mineral products needs the cooperation of the research engineer, whose investigations are of essential value to the manufacturer who extends the resources of his organization into the mining field.

Economy Trends in Handling Drill Steel

AN OLD PROBLEM of mine operation is that of avoiding the waste of labor involved in distributing and collecting drill steel. The problem is greater in underground work than in open pits, and in large mines than in small ones. Circumstances at some particular property have occasionally made possible a solution, but none thus far of general application.

Some idea of the labor involved in handling steel may be obtained from the results of an investigation made by a company to determine the tonnage of dull and sharp steel handled in twelve months in a mine having 85 working places and requiring 4,020 pieces of steel. This proved to be no less than 2,273 tons, distributed to and collected from 39 stopes, 24 sills, and 22 raises, many of them reached with difficulty.

Solution of the steel-handling problem has been at-

tempted by development of a detachable bit, and by sharpening drill steel underground. Efforts to produce a generally satisfactory detachable bit are said to date back sixty years—a period of incubation that indicates the difficulty of the task. Of the many bits devised, only one is used extensively and that largely if not wholly by one company. A successful bit will minimize the amount of steel handled, although it may not thereby decrease the total steel bill as much as might be thought, as the drill rods are subject to replacement.

Location of the drill shop underground is a not unusual but hardly common practice. Mine layout has often prevented its adoption. Much of the advantage is lost unless the shop can serve a large number of working places conveniently. The practice, moreover, has been limited to well-ventilated mines, because of the need of disposing of smoke and gases from the forge and tempering furnaces customarily used. An excellent example is found in the eastern United States at a group of three iron mines, each having three shops underground in open stopes and stations as close as possible to centers of work. Oil-fired forges are used. Here, although the ventilation is good, the possibility of substituting electric furnaces is receiving consideration.

Where the layout of workings warrants, increasing adoption of underground sharpening may be expected as ventilation conditions are improved; or, if these remain unchanged, as electric furnaces are substituted for those producing fumes. To be suitable for such work, an electric furnace must be sturdy and efficient, such as that developed and described by Messrs. H. I. Altshuler and J. T. Lewis, Jr., in *Engineering and Mining Journal* of Nov. 16, 1929. Increased appreciation of the economic importance of scientifically controlled heats for forging and annealing operations, and cheaper electric power, will speed the change.

Comparative costs will decide in every case how the problem of handling and sharpening drill steel economically is to be solved. In turn, local conditions will largely determine the costs. Rarely will a study of these conditions fail to disclose an opportunity for saving.

Essential Minerals Go a-Begging

IN SKETCHING the results of the potash program of the United States Government, at the recent annual meeting of the A.I.M.E. in New York, reference was made to the high cost of the potash purchased from other countries during the War, compared with what the imported commodity would have cost normally, as the price of unpreparedness. This observation, as pertinent now as it would have been in 1918, invites inquiry as to whether or not recent world events have changed the status of so-called essential minerals. Is the argument still forceful that a country should insure for itself a domestic supply of these commodities against emergency arising from threat of war or economic conflict? As one regards the sudden flares of hatred and animosity that spring up, now in one spot and now in another around the globe, one feels that the need of national safeguard against the hazards of aggression is as great as ever. On the other hand, hardship is forcing many peoples to recognize more clearly the advantages of a freer trade and the foolishness of building higher and higher tariff walls. But without a tariff, the fostering of infant industries in essential minerals would be impossible. Tariffs for the protection of these mineral industries must therefore be tolerated, or the difficulty presented by the resultant dilemma can be overcome only by the prior creation of a stockpile of the essential commodity. This device offers but limited security. To provide the funds necessary for such acquisition may prove as difficult as persuading legislators to grant an adequate tariff or subsidy. Nevertheless, at the present low world prices for mineral commodities, such stocks could be accumulated at a minimum cost. Countries lacking the security they desire with respect to mineral supplies, and which have taken no steps to remedy this weakness, might well seize the opportunity afforded by the present market to protect themselves, using part of the money they have provided for armament.

Air Conditioning Aids to Efficiency and Economy Underground

AIR CONDITIONING is receiving about the same degree of popular attention that mechanical refrigeration attracted several years ago, when the public first became familiar with the advantages offered then by a newly developed household unit. Theaters gave the public its first acquaintance with conditioned air—air that was cleaned, cooled, and dehumidified; then a department store adopted it for a street floor, and a hotel used it in a main dining room; finally, the railroads began experimenting with air-conditioned dining cars, and now several air-conditioned trains are in operation. But air conditioning of the home will probably develop more slowly than did household mechanical refrigeration. It will be preceded by a more effective control of atmospheric conditions in various industries than exists today.

A few applications of air-conditioning equipment have been made in the mining industry, notably at the Morro Velho mine of the St. John del Rey Mining Company, operating in the Minas Geraes district of Brazil. An ammonia cooling plant was used as early as 1922 at this property to reduce underground air temperatures to a depth of 6,000 ft. For controlling conditions in the deeper workings, where normal rock temperature is about 130 deg. F. and air temperature about 126 deg. F., an air-conditioning plant—for dehumidifying and cooling—made by the Carrier Engineering Corporation, was added in 1930. Comfortable working conditions and improved operating efficiency are being achieved in this section of the mine as a result of the installation of the plant; in addition, it is extending the probable life of the property by assuring continuance of mining at increasing depth.

With the exception of the outlet that the house-apartment-hotel field will eventually offer, manufacturers of air-conditioning equipment probably have no more important potential market than that which the mining industry affords. In nearly every mine is a section, difficult to ventilate, where atmospheric conditions could be improved to advantage. The problems involved in certain mining districts, such as the Witwatersrand, where high rock temperature at depth causes the air to become hot and humid, thereby lowering the worker's efficiency and inducing silicosis, present an unusual challenge to the

engineering staffs of equipment manufacturers and to those technical officials of mining companies who are responsible for ventilation practice. Operating efficiency, property life, health of workers, and final costs—all influential factors in any mining enterprise—are intimately linked with underground atmospheric conditions.

A suitable air-conditioning unit for general underground use will eventually be designed. It may be of large size and necessitate the employment of a permanent installation; or, perhaps, a small, mobile unit will be evolved for use in a stope or other underground opening, equipped with suitable inlet and outlet ventilation doors. But, regardless of what form or forms such equipment may ultimately take, one fact is certain: the forward-looking mining executive will familiarize himself with the progress being made in the technique of air conditioning, and will investigate the opportunity for its adoption or adaption to local conditions and requirements.

When Acid-Resistant Equipment Fails

DURING the discussion of a paper on Katanga hydrometallurgical operations, presented by Messrs. A. E. Wheeler and H. Y. Eagle at the recent meeting of the A.I.M.E. in New York, interest was expressed in the difficulty experienced at Katanga in finding equipment able to withstand the strongly corrosive action of acid sulphate solutions. Opinions were divided as to the cause; the authors appeared inclined to attribute the action to the high cobalt content of the solution—about ten grams per liter. Others put the blame on the ferric iron in the solution—about five grams per liter.

No definite attempt was made to explain why cobalt sulphate would accelerate the corrosive action of a solution of sulphuric acid. The closely related nickel sulphate—a common impurity in copper electrolytes—does not have this effect. Ferric sulphate, on the other hand, has always been in disrepute on account of its extremely corrosive action. If conditions for rapid reoxidation of the ferrous salt formed during the reaction with the nobler metal prevail, iron, in amounts below one gram per liter, has been known to cause rapid destruction of equipment. The Katanga flowsheet offers ample opportunity for aëration of the solution, and excessive corrosion is therefore to be expected.

Many examples of failure of acid-proof equipment are explained by careful study of operating conditions. An apparatus that gave excellent service in the evaporation of a corrosive liquid was destroyed in a short time after a piece of iron had accidentally been dropped into the liquid by one of the workmen. Small pieces of metal of inferior quality, used in fittings and connections, have at times had disastrous effect upon acid-proof equipment. The explanation—galvanic action—apparent to those who have made a study of corrosion, is sometimes overlooked by the average operator. Neither must the possibility of catalytic or accelerated chemical action be disregarded. An acid-resistant alloy, with copper as the main component, in one instance failed under conditions it was specified to meet. Investigation disclosed the fact that the failure was caused by the presence of finely divided manganese oxide—a strong oxidation agent.

Equipment made from corrosion-resistant metal is unavoidably expensive. Care should be taken to insure satisfactory and maximum service. An intelligent technical study of the problem and close supervision of operating conditions are essential to insure full benefit of the advantages that modern alloy technique is offering in combating corrosion.

Engineering Announcements in the Newspapers

WHEN the daily press is criticized for publishing accounts of sensational developments in engineering or technology that indicate variance from professional experience, or absence of economic or scientific promise, the retort is usually forthcoming that such announcements constitute news. Whether or not an event of interest or significance actually occurs is difficult to prove; seekers after publicity and those with an eye on the proverbial savings of widows and orphans sometimes make deceptive claims, and an editor may be excused if, in going beyond his own range of knowledge, he is made the victim of an unscrupulous or ignorant promotor, or of an enthusiastic yet unreliable inventor. On such occasions he usually passes the information to his readers without comment, hoping that it will evoke interest without stimulating critical analysis; and knowing, also, that the public is fickle and easily led. The hazards in such a course are threefold: misrepresentation may be encouraged, misinformation disseminated, and money deflected into the pockets of the unworthy, to the financial loss of the gullible.

The craze for news of this character can be satisfied and ill effects prevented by following a practice exemplified in a recent issue of the London *Daily Express*, a practice for which that publication deserves commendation, and one, moreover, worthy of emulation elsewhere: A German chemist announces a revolutionary discovery whereby gold is obtainable from lava shipped from the island of Ascension—a diminutive admiralty settlement in the Atlantic Ocean, about 800 miles from St. Helena, belonging to Great Britain. Accompanying the announcement of the evolution of a metallurgical process are statements to the effect that 1½ to 4 ounces of gold has been recovered per ton of material, and that operating costs on a commercial scale may be estimated at about five per cent of the sale price of the product.

The story is a sensational one, and the *Daily Express* gives it to its readers, but only after it has submitted the claims to a select jury of mining and metallurgical authorities—Mr. Algernon Moreing, of Bewick, Moreing & Company; Mr. Robert Allen, of the Mineral Resources Bureau of the Imperial Institute; Mr. H. L. Sulman, an inventor and metallurgist of note; and Professors B. W. Holman and S. J. Truscott, of the Royal School of Mines. These gentlemen discuss the development frankly and impartially, and their conclusions are also published. They are not afraid to give facts and to voice opinions that will hinder if not prevent the deflection of capital for the culminating "research" planned by the promotor. The incident is closed as soon as disclosed, as it deserved to be, to the advantage of prospective investors and to the credit of the profession of mining engineering.

LOW-COST SALT

An Example of Advanced Technique in Design and Construction at a Texas Mine and Plant

Plant of Morton Salt Company, at Grand Saline, Tex.

H. B. Cooley
Allen & Garcia Company, Consulting and Constructing Engineers, Chicago, Ill.

OF THE non-metallic mining industries, probably none has shown more marked progress in production methods than the rock-salt industry. With changing markets has come distinct need for more economic production and a better preparation of product. The first modern rock-salt plant was built in Kansas about seven years ago. Closely following came a model large-capacity plant in New York state[1], and later a new plant for the Detroit Rock Salt Company at Detroit, Mich.[2] Following these developments comes a modern plant in one of the oldest salt-producing regions of the United States.

The salt domes of the Gulf coastal plains of Louisiana and Texas have long been known, both for their abundance and the purity of the deposits. The first of these deposits was discovered in 1862 at Petite Anse (Avery Island), Louisiana, and is still being mined. Two additional mines are operated in this same district, one at Grand Cote (Weeks Island) and the other at Belle Isle (Jefferson Island). Only recently have any of the deposits in the northern region been mined. The first one of these domes from which rock salt in commercial quantities has been obtained is the Kleer Salt mine of the Morton Salt Company, Grand Saline, Tex. Existence of the Grand Saline salt dome has long been known, and an evaporating plant, also owned by the Morton Salt Company, has been pumping brine from this source for many years. During this time the need for those grades of salt that can be produced only by mining methods became apparent, but the difficulties of sinking a shaft through the measures directly above the salt strata seemed prohibitive. Records from drill holes available indicated that at least portions of the salt dome were overlaid with an underground water flow of about 80-lb. pressure. After a thorough engineering study based on data obtained from ten additional drill holes, a decision was made to attempt the sinking of a shaft under these conditions. The Allen & Garcia Company was commissioned to design the shaft, and the Dravo Contracting Company selected as contractors for its construction, with the exception of using the Francois cementation process through the water-bearing stratum.

Difficulties encountered and the methods used to complete a finished shaft to the mining level successfully have been previously described by Mr. M. Taylor,[3] of Pittsburgh, Pa. As stated in his description, the shaft passes into the salt at a depth of 210 ft. from the surface, but sinking in salt was continued to a depth of 700 ft., where previous core drillings indicated a superior grade of salt, with excellent crystalline structure. Shaft walls are of reinforced concrete for the entire depth, with an inside diameter of 14 ft 6 in. and of varying thickness to resist the hydraulic pressure encountered at various depths.

Arrangement of the shaft compartment, shown in Fig. 1, is interesting; first, because upcast and downcast air are carried on opposite sides of a continuous partition wall, and, second, because of the bunton and guide arrange-

[3] *Mining & Metallurgy*, December, 1930.

Mining room with scraper in foreground

[1] "A Model Salt-Mining Plant at Retsof, N. Y.," *Engineering and Mining Journal-Press*, June 21, 1924.

[2] "Mining Rock Salt in Michigan," *Engineering and Mining Journal*, July 10, 1930.

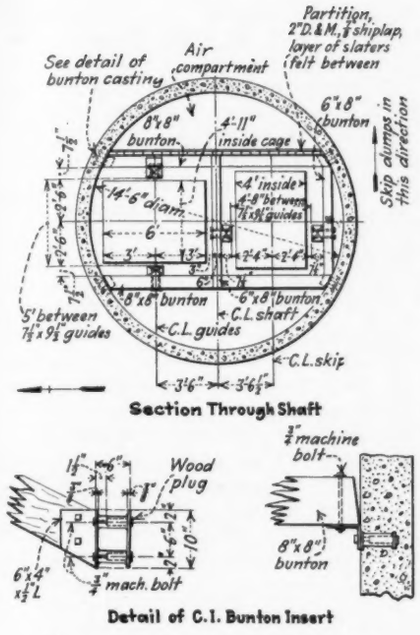


Fig. 1—Cross-section of shaft and bunton details

ment to accommodate one skip and one cage. Ordinarily, a choice is made between a skip- and a cage-hoisting system by weighing their relative advantages and selecting either one or the other. The combination of one skip and one cage is unusual, and it was employed after a careful study, to secure the advantages of both systems.

Experience in other rock salt mines has shown that the salt, even with careful blasting, frequently breaks in lumps of large size that weigh 500 lb. or more. If the size of the mine cars used be such that they can be hoisted in a shaft of normal size, these lumps must be redrilled and blasted, even though the mechanical loading equipment available may be able to handle them. It therefore seemed obvious that the transportation system from the loading face to the shaft bottom should be selected without regard to the size of the equipment that could be hoisted in the shaft. Inasmuch as rock salt in sizes as obtained in normal blasting requires two-stage crushing, the further advantage of placing the primary crusher on the shaft bottom was to be had when hoisting in a skip.

When the hoisting arrangement consists of two skips in balance, the problem of handling men and material is not easy. Skips can be provided with a man-deck that may be either permanently attached to the skip bail or arranged for removal when not in use. However, a simple cage without a tilting platform is the ideal unit for handling men and material. Inasmuch as the daily production was not expected to exceed 100 tons per hour, a suitable hoisting cycle could be secured by combining a single skip of 4-ton capacity with a platform cage to act as a counterweight, as shown in Fig. 2. Fig. 3, showing the design of the drum, and the hoisting details presented in the accompanying table, indicate the convenient features provided, which are not obtainable with either ordinary balanced-skip hoisting or balanced tilting cages. With either of these systems the hoist operator must make a special stop at the ground landing when men or material are loaded, whereas, with the design adopted, the skip travels its full distance from loading point below the mine-floor level to dumping point on the surface, while the cage is traveling a shorter distance —that is, from surface landing to the mine-floor level.

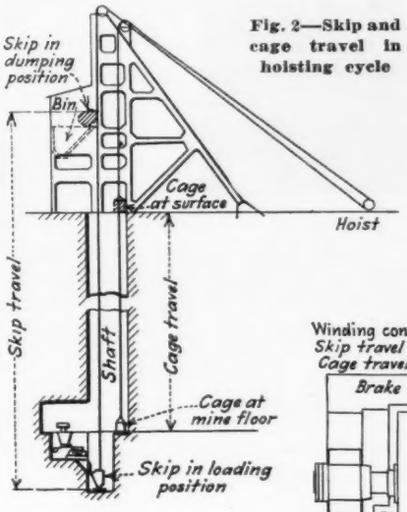


Fig. 2—Skip and cage travel in hoisting cycle

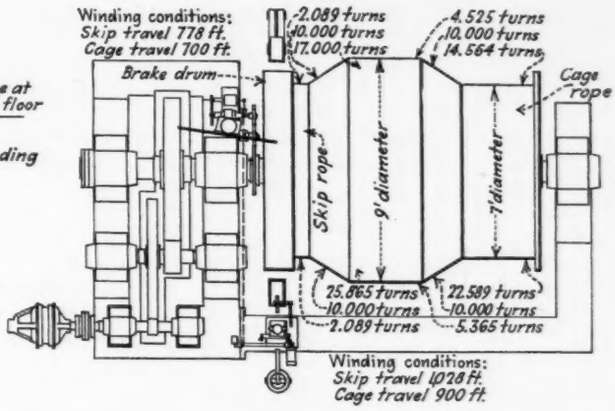
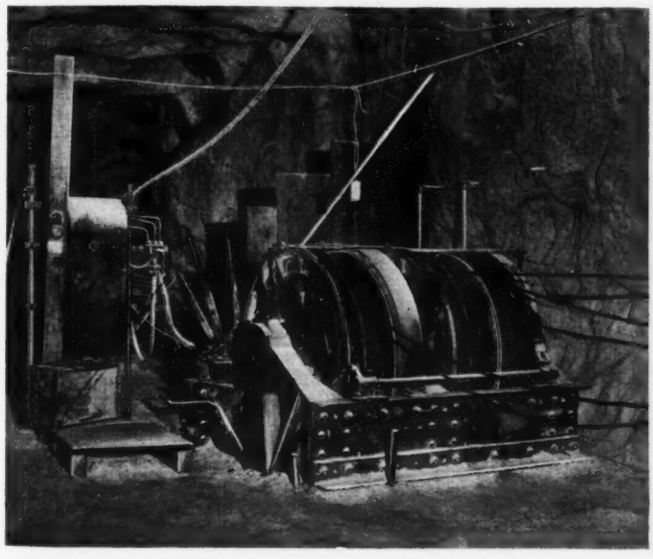


Fig. 3 — Drum and hoisting arrangement

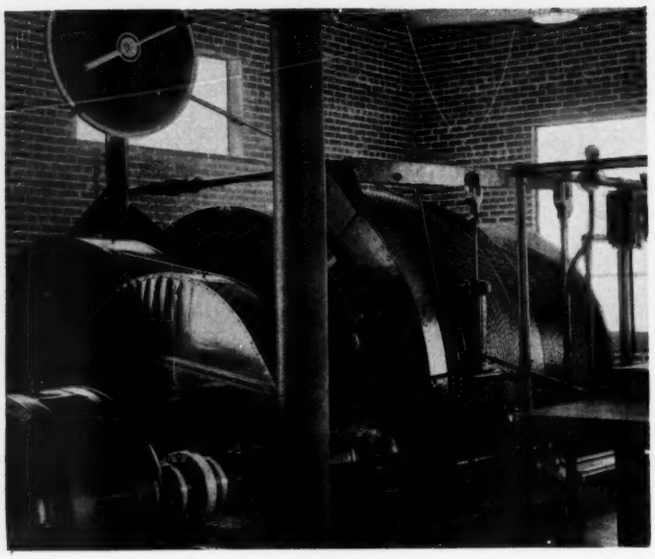
Two hoisting conditions were imposed—namely, that a mining level be established at 700 ft., with provision for increasing this hoisting depth in the future to 900 ft. That this change will ever be made is improbable, because the quality of the salt at the present 700-ft. level is unsurpassed, and the total tonnage available at that level is sufficient for many years. Additional drum capacity, however, was obtained at small cost, and should the quality of the salt at this level become inferior at any time, mining at a lower level can be readily undertaken.

Experiments with a mining method quite different from that used in the Southern salt domes are being conducted at the property. Preceding a description of this method, several features peculiar to the Grand Saline salt dome deposit might well be mentioned. First, with a salt depth of 700 ft. over an area one mile in diameter, both the vertical and horizontal dimensions are so extensive as to make the normal tonnage available for centuries. Second, the deposit is so uniform, with neither vertical nor horizontal seams nor cleavage planes, that the mining method adopted need have no reference to the way in which the deposit was laid down. Third, neither water nor gas is present, and the character of the roof is such that no failures have ever been reported.

When mining at Avery Island was



Movable scraper hoist which is advanced with the mining face



Main hoist serving skip and cage

started, chambers 30 ft. wide by 30 ft. high were driven checkerboard fashion. Over a period of years the dimensions of these chambers have been increased to 60 ft. high and 60 to 80 ft. wide, leaving rectangular pillars about 60 ft. square. Electric shovels of from ¾- to 1¼-yd. capacity are used to load mine cars, which are hauled to the shaft either by mules or trolley motors. This method has probably resulted in material-handling costs that have been comparable with those obtained at the most efficiently operated open-pit or underground mines. But, in an endeavor to avoid the expense of reshooting lumps and the transfer of material by electric shovel to car and thence to the primary crusher, a system of scraper loading has been developed at Grand Saline.

A Goodman, Type 436, three-drum scraper hoist, with *V* type bottomless scoop of 2 tons' capacity, replaces a loading shovel and mine cars, the scraper traveling the full distance from the loading face to the shaft bottom. A schematic comparison of the shovel- and scraper-loading methods is shown in Fig. 4. Rooms are driven 60 ft. wide by 60 ft. high in both systems. With the shovel-loading method, the "first-mining" cut is carried in for a distance of from 200 to 400 ft. at a minimum height for convenient shovel loading—about 20 ft. high. The salt above this roof is shot down from a series of "hanging walls," the loose salt serving as a support for the drilling crews. This method has a peculiar advantage in that large volumes of loose salt shot down during the dull season are available for loading during the busy season.

Details of the scraper-mining method and of the development procedure employed with it are presented in Fig. 5. In applying this method, an inclined heading is first driven on a 20 deg. slope, the toe of the slope being near the shaft bottom. When this heading reaches the proper height for a 60-ft. room, the "first-mining" cut is continued horizontally and operations are started on the sloping face. Holes are drilled vertically downward at about 3-ft. intervals and to a depth of 6 ft. After shooting the salt from the face of the slope, it is dragged to the shaft bottom by scraper hoist. This system has been in use for nearly a year, and is just beginning to reach the limit of economical operation for the present position of the hoist.

Work is in progress preparatory to turning the first two rooms at right angles to the present workings. The scraper hoist will then be moved forward, away from the shaft bottom, and a belt conveyor used for carrying the salt from the new discharge point of the scraper to the shaft bottom. When this move is completed and the scraper hoist set in its new location, about two years' tonnage will be available, without further change in either the position of the hoist or the length of the belt conveyor. At the end of that period the hoist will again be moved forward and a second unit of belt conveyor added, strain permitting several years' operation before moving the hoist. Ventilation is provided by 8x8-ft. airways, driven on the "first-mining" level and so arranged that break-throughs are easily driven to provide air at the most advanced working place.

Rock-salt milling practice in the Gulf coastal field differs from that employed in other parts of the country, owing chiefly to the purity of the salt, which makes it suitable for table use, as well as for water softening, meat packing, stock feeding, and the chemical and ceramic industries. The milling process, as indicated by the flowsheet presented in Fig. 6, is really that of a coarse-salt mill, producing grades similar to those marketed in the mines of New York, Michigan, and Kansas, combined with a fine-salt mill, equipped to produce grades more comparable with those marketed by the evaporating plants in these same areas. Although the flowsheet might be so interpreted, the actual plant layout is not arranged so that the two milling systems are segregated. The bins and screens and other mechanical units are all grouped with a regard for economical construction and minimum operating attendance and to make the entire plant a single operating unit equipped to produce what would ordinarily be considered mill grades of salt of two distinct types.

A division of the milling operation into two parts was, however, found advisable for other reasons. As seen in the accompanying general view of the plant, it consists of two independent structures connected by an inclined belt-conveyor gallery. The smaller of the two structures is above the mine shaft. For the safety of the men underground, this entire unit is fireproof, the structural portion being of reinforced concrete with a covering of corrugated asbestos. Should a serious fire occur in the mill building, the fireproof headframe would still insure safe operation of the man-cage in the shaft.

Within the headframe structure, the salt receives its primary treatment before being conveyed to the main mill. After having passed through a primary crusher situated on the shaft bottom, the salt is hoisted to the surface and dumped into a 30-ton reinforced-con-

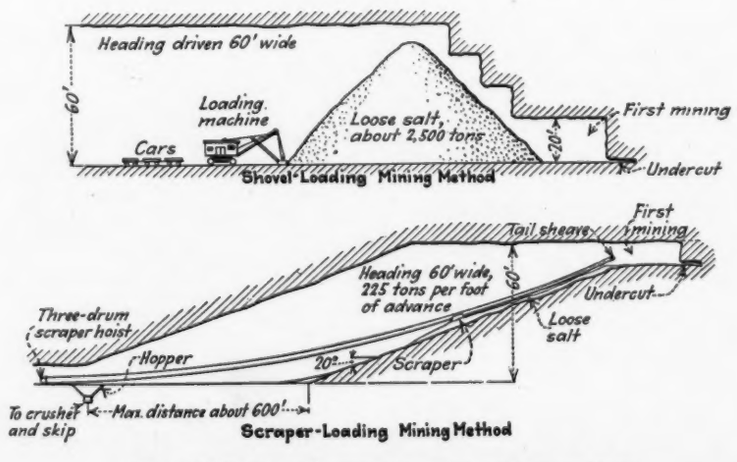


Fig. 4—Shovel- and scraper-loading mining methods

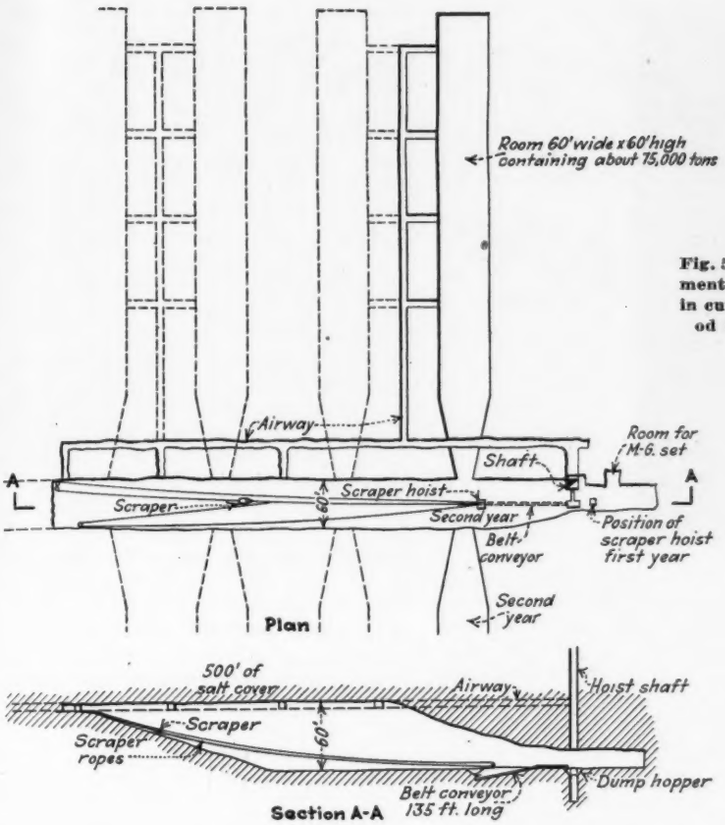


Fig. 5—Development procedure in current method of mining

crete storage bin, lined with vitrified brick. From this bin the salt is conveyed by means of a reciprocating plate feeder to a shaking picking table, designed to bypass the minus 1-in. fines and permit inspection of all plus 1-in. pieces. This inspection table provides an opportunity to remove shot wire and lumps of salt stained by powder smoke, as well as any foreign material, such as tamping sticks, that may have been inadvertently loaded.

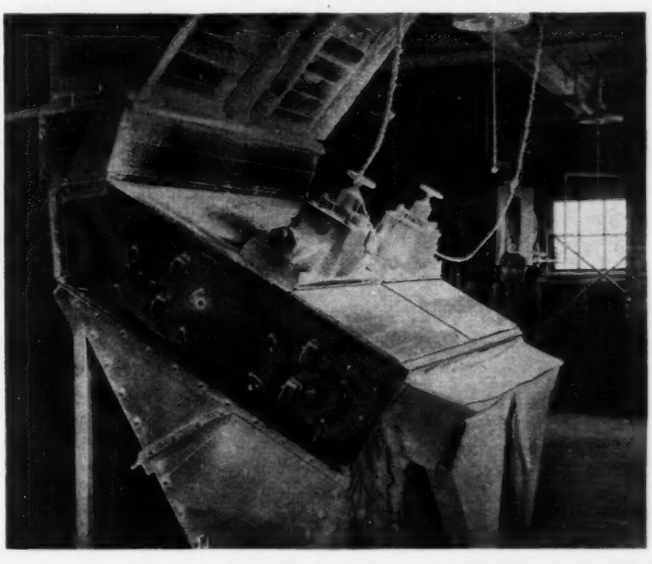
An occasional piece of "discolored salt" is also found and removed, and, after being removed from the picking tables, is stored in a small gob bin on the floor below, where provisions are made for crushing it. The crushed product is sent to a brine tank, made of reinforced concrete and brick, and so arranged that after the salt is dissolved the saturated solution can be pumped to an evaporating plant near by and the insoluble material, precipitated in the bottom of the tank, flushed out periodically.

After the salt is inspected at the picking tables, it is crushed to about the size of 1-in. cubes. An 18-in. rubber belt conveyor, on a 15-deg. incline, carries this crushed product to the main mill. A magnetic head pulley removes all pieces of tramp iron. The accompanying flowsheet shows the milling process and the number of grades into which the salt is sized. A noteworthy feature is that all of the sizes produced in the fine-salt mill—that is, the granulated, medium, and table salt—are made not by screening of the mill run below 10 mesh but by grinding of some of the larger sizes. Experience has shown that the best grades of fine salt, those with the most uniform crystals, are produced by grinding large crystals of some particular size. No. 1 salt (— $\frac{3}{8}$ in. + 4 mesh) and the *A* grade (— 4 mesh + 6 mesh) seem to be most adaptable for regrinding at Grand Saline. Nearly 10 per cent of the tonnage of raw salt from the mine is minus 10 mesh. This material, removed by screening, is stored in separate bins and either sold in bulk as a distinct product or sent to the brine tank, where it is dissolved and pumped to the evaporating plant.

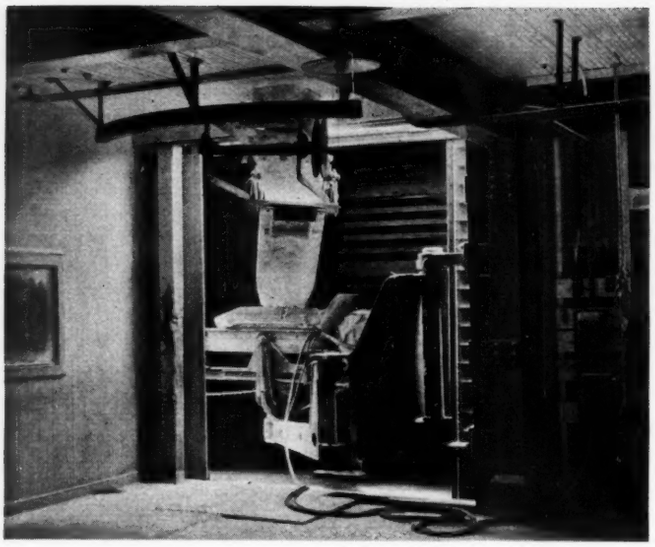
After the milling operation is completed, the various grades pass either by chute or conveyor to a series of bins, the bottoms of which are near the third floor level. From these bins the salt is drawn off to be packed or loaded. The second floor, 60x90 ft., is used exclusively for packaging. Two Hoepner bagging machines travel on a track that extends the full length of the series of coarse-salt bins; the fine sizes can also be spouted to these machines. Two stationary machines are available for filling small sacks, which range from $1\frac{1}{2}$ to 10 lb. in size, and a complete mechanical unit for packaging table salt in rectangular pasteboard cartons, which may be wrapped with wax paper, also provided.

The second floor contains, in addition, two belt conveyors that extend the full length of the room. The first of these is used for carrying any one of the six coarse sizes to a Manierre box-car loader. Bins containing three sizes below 10 mesh have sufficient height so that a flexible hose from the bin bottom to the car door permits these sizes to be loaded in a manner similar to that used in bulk loading from grain elevators. A special grade of extra-heavy rubber hose is used as a spout. The second belt conveyor is in two units, each being reversible. As bags are filled by the Hoepner portable machine, they are loaded onto one of these two units and carried to any one of three points that is, at the time, most convenient for either loading into railroad cars or for storage on the first floor.

The entire first floor, 60x120 ft., is used for the storage of packaged salt. Railroad cars, with their doors at the first-floor level, extend lengthwise on either side of the building. Ordinarily, one side is used for loading bulk salt and cars that are to contain both bulk salt and salt in bags. The other side is used exclusively for loading salt packed in bags and cartons. The mechanical layout of the mill can be said to follow, in general, that indicated by the flow-



Electrically vibrated screens size the products



Salt for bulk shipment is placed in box cars with this loader

sheet, except that the actual grouping of the units is much more simplified than might be judged from the flowsheet. Corrosion presents one of the most perplexing problems in the design of a mill for handling salt. The protection of structural members is a problem, but to keep rust specks out of the fine-salt sizes is one of even more importance. Use of alloy metals, such as Monel, and the adoption of a porcelain glazed lining for the smaller feed receptacles, prevent some of this trouble. For larger chutes and storage bins, these refinements are prohibitive in cost. All chutes and hoppers that had to be made of steel were hot-dipped galvanized after being fabricated. The cost for this added protection from rust for about nine tons of sheet metal chutes and hoppers was $350; more than this amount will undoubtedly be saved by avoiding the cost of painting.

Storage bins of 40 to 120 tons' capacity are built with laminated timber wells supported by structural steel. The interior walls of the bins are lined with maple flooring that soon becomes smooth from the flow of salt and thereafter shows practically no signs of wear. Reinforced concrete bins for salt storage have been used at similar plants, and have given excellent service. The difficulty in rearranging partitions, cutting holes for additional feed spouts and other changes necessitated by new milling practice and methods of preparation, made it advisable to consider concrete bin construction at Grand Saline.

Preliminary comparative designs for the mill were made, using all-timber construction and a composite of wood and steel. Estimated costs, based on these designs, revealed definite economy in first cost for the composite design. An added feature of this design was the elimination of closely spaced columns, a clear span of at least 26 ft. being desirable on the second floor, to permit a proper grouping of the portable bagging machines with relation to the stationary packaging machinery. Following the decision to use combined wood and steel bin construction, a similar type of design was adopted for the floor and roof construction. Steel H columns are used, with steel girders between columns. Wood floors are laid directly on these steel girders, using 2-in. lumber placed edgewise. These laminated floors are 4, 6 and 8 in. thick, the thickness being determined by span and floor loads. The roofing and siding are of Johns-Manville corrugated asbestos. Heating is provided on the second and screening floors by unit heaters, fired by natural gas, with forced fan blowers.

A list of the grades of salt produced at the plant, with the size limits of each grade, follows: No. 3, —1 in. + $\frac{5}{8}$ in.; No. 2, —$\frac{5}{8}$ in. +$\frac{3}{8}$ in.; No. 4, —$\frac{3}{8}$ in. + 3 mm.; No. 1, —$\frac{3}{8}$ in. +4 mm.; No. A, —4 mm. +6 mm.; No. C, —6 mm. +10 mm.; granulated, —12 mm. +30 mm.; medium, —10 mm. +12 mm.; untreated table, —30 mm. +50 mm.; treated table, —30 mm. + 50 mm.; mine fines, —10 mm. + 0; mill C, —10 mm. +40 mm.; dust, —50 mm. +0.

Hoisting Details

Weight of skip, lb.	8,000
Weight of skip load of salt, lb.	8,000
Total weight, lb.	16,000
Weight of cage, lb.	6,000
Weight of cage counterweight, lb.	4,750
Total weight, lb.	10,750
Unbalanced load, including rope weight, skip ascending, lb.	7,450
Unbalanced load, including rope weight, skip descending, lb.	4,950
Diameter of rope, in.	1¼
Rope speed, feet per minute	460 to 581
Drum speed, revolutions per minute	21
Dimensions of cylindro-conical drum:	7 to 9 ft. in diameter
Total available turns:	
On large diameter	27
On small diameter for cage	26
On small diameter for skip	5
Brake, 8 ft. in diameter, hydraulically operated	
Motor, 150-hp., 600 r.p.m., 2,200 volts, 3 phase, 60 cycle, General Electric, Type MTC.	

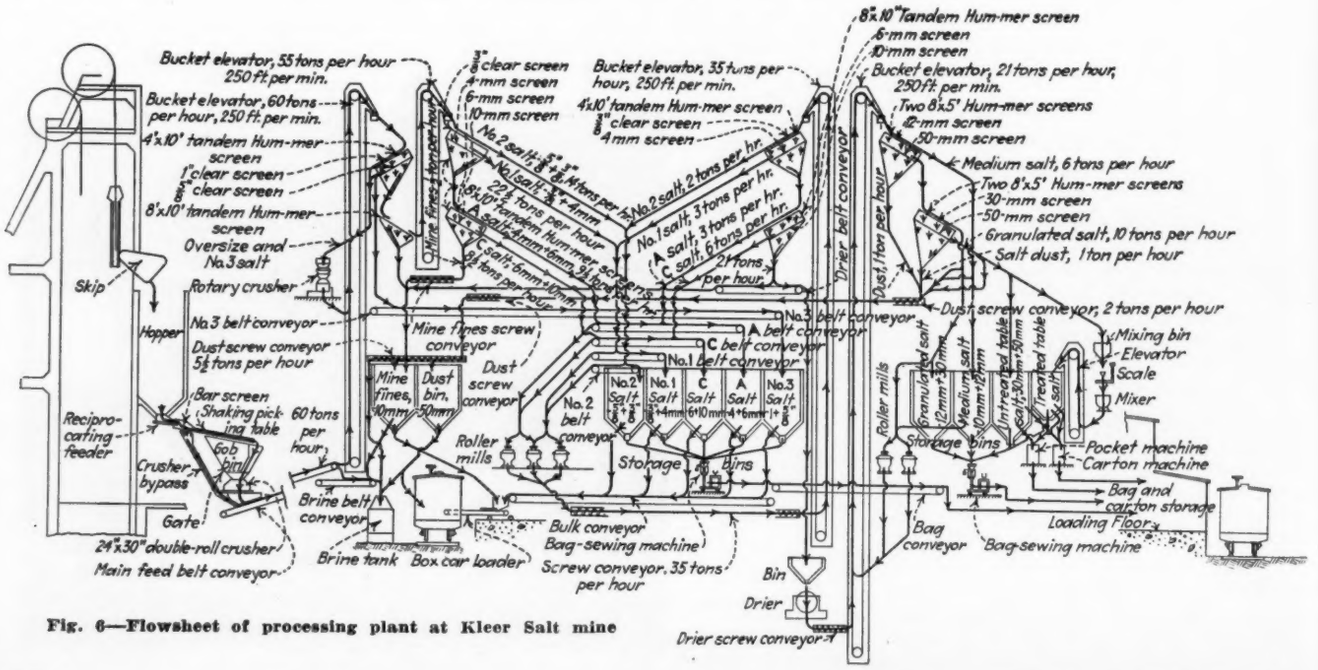


Fig. 6—Flowsheet of processing plant at Kleer Salt mine

Lubrication and Economics

E. R. Woodward

Following the proper selection of lubricants, discussed in a previous article, the consideration second in importance in controlling the economics of lubrication is that of efficient application. A broad survey of the various types of equipment used in the mining industry indicates that lubrication needs are varied. Some examples of the best practice in vogue are herewith presented.

IN STARTING A NEW DRILL or boring machine, or following a short period of idleness, oil should be poured into the throttle valve before connecting the hose line to it; otherwise the drill should be turned up and some oil poured into the chuck end. Constant attention should be given to drill lubrication, the oil reservoirs being filled at two-hour intervals during operation, or if line oilers are used they should be filled twice per shift. For valve and cylinder lubrication of air-driven rotating hammer drills an oil of Saybolt viscosity, 42 to 46 sec. at 210 deg. F., is recommended. Oils lying within this viscosity range have sufficient body to withstand the heaviest blows and the necessary fluidity to allow maximum penetration of the drill steel.

In using air-driven hammer drills operated with a water attachment, a light-bodied, compounded, filtered cylinder oil is recommended, having a Saybolt viscosity of 95 to 105 sec. at 210 deg. F., containing up to 10 per cent of compound. Emulsion-forming characteristics prevent it from being washed away by water, as straight mineral oil would be. For valve and cylinder lubrication of steam driven drills, a valve oil having a Saybolt viscosity of 130 to 140 sec. at 210 deg. F., containing up to 6 per cent of compound, is required. Correct body is important, to afford maximum atomization and distribution. Rotating mechanism is best lubricated with a soft lime-base grease of about 203 deg. F. melting point, and 270 to 300 A.S.T.M. unworked consistency. Quenching and hardening of drill steel involves an important application of oil. Grain structure of steel continues to improve with rising heat, until the critical temperature is reached. At this point if the steel be quenched, or cooled rapidly, the structure can be preserved in the cold steel. Plain water is best for quenching bits, and a mixture of one part of good grade soluble cutting oil with ten to fifteen parts of water is best for quenching shanks. Water quenching gives a bit with the hardest structure; soluble-oil quenching gives a softer structure. A good quenching emulsion may be used repeatedly, giving uniform results.

As in most lubrication problems, temperature is a governing factor in the lubrication of air-compressor cylinders. The chief effects of elevated temperature in this connection are: (1) Reduction of the body or viscosity of the oil; (2) decomposition of the oil to form excessive carbon deposits. These deposits lead at first to inefficient operation, because of the sticking or partial closing of valves, and in more advanced stages may readily lead to explosions or fires caused by incandescent particles of carbon coming into contact with oil vapors. For these reasons the correct oil should be used for air-compressor cylinder lubrication.

Small single-stage compressors up to 150 lb. (including portables), with high-discharge temperatures up to 410 deg. F., require a heavy-bodied air-cylinder oil having a Saybolt viscosity of 100 to 115 sec. at 210 deg. F. Larger compressors, in which discharge temperatures do not rise above 260 deg. F., are satisfactorily lubricated with a lighter-bodied straight mineral cylinder oil having a Saybolt viscosity of 45 to 55 sec. at 210 deg. F.

A satisfactory oiling system for angle-compound compressors provides positive lubrication for crankshaft bearings, crank pins, crosshead shoes, and pins. Oil is pumped from the crank chamber up a standpipe into a reservoir, whence it is distributed to the bearings. Sight feeds at various points allow observation and adjustment of the oil stream, excess oil being returned to the crank chamber through an overflow pipe. Check valves prevent drainage of the system when the compressor stops, but a liberal supply of oil should be poured into the reservoir on top of the standpipe, leaving the sight feeds open in order to be sure that all bearings have sufficient oil before starting.

The cylinders are lubricated by a force-feed pump driven by a rod from the main gravity pump. One feed line enters the top of the low-pressure cylinder near the center. Another line feeds the high-pressure cylinder via the intake pipe. Air from the intercooler carries the oil into the cylinder. Rate of feed for each point lubricated should be about one drop per minute. However, instead of adhering to any definite number of drops per minute, the better method to insure adequate lubrication is to adjust oil feed after taking out the valves at intervals and examining the cylinders. Any dryness or excess of oil will at once be evident.

Lubrication of the engines operating air-driven mechanical loaders is effected by feeding oil into the main air line by means of a force-feed automatic lubricator. This also supplies oil to the main engine bearings. A high-grade compounded air-compressor oil, 60 to 65 sec. Saybolt viscosity at 210 deg. F., containing up to 7 per cent of compound, is recommended. With the exception of the engine journals, all bearings of mechanical loaders are usually lubricated with grease. Grease cups were formerly used, but high-pressure greasing systems have been installed on the later models, with improved results. For this purpose, a high-pressure grease of about 203 deg. F. melting point, and 270 to 300 A.S.T.M. unworked consistency, is recommended. An unfiltered oil of 60 to 65 sec. Saybolt viscosity at 210 deg. F. is preferable for lubrication of the inclosed bronze worm gear, the housing being kept at least half full of this oil.

If steam is used to drive excavating equipment or cranes, considerable condensation takes place in the steam chests and cylinders. Compounded oil, which emulsifies and clings to the internal surfaces, must therefore be used. The washing action of condensed steam removes straight mineral oil, leaving the internal surfaces without lubrication. In addition, the oil must have a viscosity that will allow complete atomization, so that the steam can carry it to all parts requiring lubrication. For this purpose, a steam-refined cylinder oil, 140 to 180 sec. Saybolt viscosity at 210 deg. F., containing about 5 per cent of compound, is recommended.

The modern six-cylinder Diesel engine—a dust-proof power plant—is also used to drive mine-plant machinery. One of the chief lubrication difficulties with the Diesel engine is caused by contamination of the oil with carbon. A high-grade oil with maximum resistance to breakdown under operating conditions is therefore essential. For Diesel engines up to 25 brake horsepower per

cylinder, a high-grade filtered oil of 50 to 55 sec. Saybolt viscosity at 210 deg. F. is recommended; and for Diesel engines of 25 to 100 brake horsepower per cylinder, a high-grade filtered oil of 60 to 65 sec. Saybolt viscosity at 210 deg. F.

During an investigation of mine-car friction with various types of trucks, M. D. Hersey and others found diversity of opinion among truck manufacturers as to lubricants recommended. For ball and roller bearings the manufacturers recommended lubricants ranging from the thinnest oil to a hard cup grease. The work of these investigators, however, proved that the running friction of ball and roller bearing trucks is usually greater with a heavy grease than with a light one. The friction of one of the roller bearing trucks originally lubricated by the manufacturer with a stiff cup grease was reduced to one-third by lubricating with light oil.

A leading manufacturer of roller bearings has developed grease inclosures at both ends of the spindle, so that grease cannot get out; nor can dirt get in. This prevents waste of lubricant. The bearing chamber forms a reservoir of sufficient size to hold a year's supply of grease under normal working conditions. A light grease, composed of a lime-soap base and a light filtered spindle oil of 200 sec. Saybolt viscosity at 100 deg. F., is recommended. Table I gives lubrication costs of mine cars with plain bearings, as compared to cars with tapered roller bearings. It is taken from a certified performance survey.

Table I—Mine-Car Lubrication Costs

	Plain Bearing Cars	Tapered Roller Bearing Cars
Lubricant, plain cars, 8,750 gal. @ $0.085	$743.75	.....
Lubricant, roller bearing cars, 3,870 lb. @ $0.080	.....	$309.60
Labor, plain cars, 2 men 8 hr. 260 days @ $0.40 per hr	1,664.00	.....
Labor, roller cars, 160 man-hours @ $0.50	.....	80.00
Total lubrication cost per year	$2,407.75	$389.60
Annual total per car	$3.44	$0.45
Annual saving per car (85.9 per cent)	.....	$2.99
Daily total per car	$0.0132	$0.0017

Ball or roller bearings do not require a lubricant in the ordinary sense. They have been known to run with less friction loss in a dry condition, but the presence of oil or grease is necessary to protect them from corrosion and to facilitate contact between ball and cage. As already mentioned, a light, chemically neutral grease may be used, or a good-quality mineral oil free from acidity, having a Saybolt viscosity of about 200 sec. at 100 deg. F. Graphite should not be used as a lubricant for ball or roller bearings.

Wire ropes frequently fail because of corrosion of the inside wires, though the outside wires are apparently in good condition. The chief requirements of a wire-rope lubricant that acts as a preservative are: (1) ability to penetrate to the center, so that the core becomes saturated and excludes water; (2) ability thoroughly to coat the inside wires of each strand. A wire rope in use is continually subjected to outside wear of drums, sheaves, and rollers, and to inside wear from friction due to the wires in the strands moving slightly when the rope is bent.

Wire-rope lubricants are either oils or compounds. The former, known as chain or cable oils, usually come in two grades: (1) a heavy mineral black oil with a Saybolt viscosity of 90 to 100 sec. at 210 deg. F.; (2) a medium-bodied zero cold-test mineral black oil, for use in cold weather; this oil has a Saybolt viscosity of 60 to 80 sec. at 210 deg. F. Each may be applied with a brush.

Chain or cable compounds also come in two consistencies: (1) a soft, viscous and tenacious dark product, to be applied by brush or swab (best results are obtained by heating before application); (2) a medium chain or cable coating, harder in consistency than the soft grade, with a melting point of about 111 deg. F., to be used where less lubrication and more protection is desired.

In considering their lubrication, hoists may be divided into those with motors inside the drums and those with motors outside the drums. On the first type oil should be used, whether the hoist be powered by electricity or by air. A medium-bodied high-grade motor oil with a Saybolt viscosity of 43 to 48 sec. at 210 deg. F. is recommended.

For hoists with motors outside the drums, a light-bodied high-pressure grease with melting point of about 203 deg. F., and an A.S.T.M. unworked consistency of 270 to 300, is recommended. This will lubricate all bearings and the motor-drive gears inclosed in the gear case at the end of the motor. For the chain drive a heavy grade of steam-cylinder oil, with a Saybolt viscosity of 135 to 165 sec. at 210 deg. F., is considered best. A hard grease with melting point about 210 deg. F., and an A.S.T.M. unworked consistency 115/125, is recommended for the clutch internal gear and pinion.

Careful consideration is being given to the lubrication of gyratory crushers by leading manufacturers. In one instance, an oil pump of the spur-gear type, inclosed in a tight housing that rotates with the eccentric, supplies lubrication to the eccentric bearings, and also to the gears and brass wearing ring that supports the eccentric. If the oil supply is adequate, the pump is entirely submerged, thus assuring a continuous flow of oil up through the inside eccentric bearing to a chamber at the top. From this chamber it flows down through oil grooves in the outer eccentric bearing. Surplus oil passes through an oil duct in the center hub to the gear chamber, where it effectively lubricates the gears. For crushers having a circulatory oiling system of this kind a good grade of filtered oil having a Saybolt viscosity of 45 to 50 sec. at 210 deg. F. is recommended. The eccentric is the controlling factor in crusher lubrication, and other types of oil are required according to the type of construction. Thus, gyratory crushers having a short eccentric operated by bevel gears, and lubricated by an oil bath, a splash, or a circulatory oiling system, require a crankcase oil of Saybolt viscosity 95 to 105 sec. at 210 deg. F.

In using a gyratory crusher for heavy-duty service, having a short eccentric operated by bevel gears, a short shaft, and a circulatory oiling system, a heavy steam-cylinder oil should be preferred both for eccentric and for countershaft lubrication. An oil with Saybolt viscosity 130 to 145 sec. at 210 deg. F. is suitable.

Lubrication of the bearings of crushing rolls is important, because of its relation to reduced wear of bearing metal. The alignment of rolls is readily affected by undue wear, and if by chance one bearing has become worn to the extent of lowering the shaft appreciably, it should be relined; otherwise, the faces of the roll shells will wear hollow.

The main bearings should be lubricated with a heavy oil or grease. If the oil is circulated and continually reused, it should be of high quality, having a Saybolt viscosity of 60 to 65 sec. at 210 deg. F. For oil-bath lubrication of roller bearings on crushers of the roll-jaw type, a steam-cylinder oil having a Saybolt viscosity of 130 to 145 sec. at 210 deg. F. is recommended. Roll bearings provided with pockets for holding grease against the rotating journal require a hard-block grease or tunnel-bearing grease. The lubricating oil contained in the grease is fed by frictional heat, assisted by the wiping action of the revolving journal.

Jaw crushers, pitman bearings, main bearings, and jaw-shaft bearings are in general lubricated with grease. Hard-block greases have latterly replaced wool-yarn grease. The consistency of the grease should vary according to the method of application, block greases fed from grease pockets being hard, cup grease being medium, and high-pressure grease fed from a gun being soft. Because of heavy duty service in most large crushers, block-grease lubrication is most suitable. For the lubrication of swing-hammer mills, oils similar to those recommended for gyratory crushers are suitable.

Main-trunnion bearings of rod mills may be lubricated by a heavy cylinder oil, with wool waste packed in the space over the journal to regulate the feed.

A better plan is to use prepared wool-yarn grease, specially made up for this type of service by leading oil companies. This is usually a combination of long-strand wool yarn and a fiber grease, which, when placed in contact with a revolving shaft, allows a slow and constant feed of lubricant to the bearing. It is specially suited for use in bearings of the over-fed type. Countershaft bearings of rod mills of the ring- or chain-oiling type should be lubricated with a high-grade motor oil having a Saybolt viscosity of 45 to 55 sec. at 210 deg. F.

On account of the severe service to which the bearings of vibrating screens are subjected, lubrication is a determining factor in their life. Such bearings are expensive to buy and to install, and proper lubrication can therefore effect definite economy and minimize operating delays. The most modern method is to use a high-pressure grease gun, the castings being fitted with the necessary nipples to receive the lubricant and conduct it to the bearings. A high-pressure grease having a melting point of about 203 deg. F. is suitable. In introducing grease, avoid entirely filling the housings, as this may cause temporary heating from increased friction.

In underslung worm gears, the oil level should be kept at the center line of the worm shaft. With other worm gears, the bottom teeth of the wheel should always be immersed in the oil. For inclosed worm gear, spur gear, spiral bevel, and herring-bone units of large size, in which the oil is supplied from an oil reservoir, a steam-cylinder oil having a Saybolt viscosity of 130 to 145 sec. at 210 deg. F. should be used. If applied by means of wick-feed oil cups or ring oilers, a high-grade lighter oil is required. One having a Saybolt viscosity 48 to 65 sec. at 210 deg. F. is suitable. An oil in this viscosity range should also be used for open worm gears and open spur gears lubricated by ring oilers or by drop feed. If such open gears are oiled by hand or by slush pans, a gear coating should be used. This is a viscous dark-colored petroleum product specially suited for the lubrication of all kinds of exposed gearing.

Occasional inspection of pump bearings is necessary to check conditions of wear. Roller bearings should be lubricated with a soft high-pressure grease, or with a well-refined Vaseline (petrolatum). For ring-oiled sleeve bearings, an oil having a Saybolt viscosity of 48 to 52 sec. at 210 deg. F. is recommended. Periodic inspections should be made to be sure that the oil rings are turning freely and that enough oil is being supplied to the bearings.

Steam engines require both cylinder oil and engine oil. Steam-cylinder oils vary widely in their characteristics, according to the operating conditions to be met in the cylinders of the engine. Thus straight mineral cylinder oils and compounded cylinder oils are used. Both types may be either filtered or unfiltered, thus making four kinds of cylinder oil.

In a compounded cylinder oil a proportion of animal oil is mixed with straight mineral cylinder oil under the correct conditions of time and temperature. These oils are suitable for wet steam conditions, because they will form an emulsion with the condensate in the cylinder and adhere to the cylinder walls. Under these conditions, a straight mineral oil, because of its tendency to separate from water, would be washed off, depriving the cylinder walls of the necessary protection of a lubricating oil film.

For dry steam and high steam pressures, straight mineral cylinder oils are required. A high demulsibility is necessary in an engine oil for use in a circulating lubrication system. Such oils are sometimes referred to as circulation oils. In systems where the engine oil does not circulate for re-use, a cheaper engine oil may be used.

Steam-turbine lubrication is controlled by the design of the machine and by the lubrication system. For most turbines above 150 kw., force-feed lubrication is in general use, employing a circulation oil of highest grade. Overheating is prevented by passing the oil through a cooler. Turbines must be lubricated with straight mineral oils of highest quality. They should have a Saybolt viscosity within the range of 42 to 65 sec. at 210 deg. F., the lighter oils being for straight-line turbines and the heavier for reduction-gear turbines. Turbine oils should preferably be of paraffin base; they must have high demulsibility and offer maximum resistance to sludge formation.

In gas engines, if cylinder lubrication shows excessive oil consumption—over 1½ grams per brake-horsepower hour—a so-called non-carbon oil should be used. This is a pale asphalt- or naphthene-base oil having a low carbon residue. The addition of 4 or 5 per cent of compound has also been found advantageous. Ring-oiled main bearings should be lubricated with a straight mineral or circulation oil.

For Diesel engines up to 100 brake horsepower per cylinder, it is customary to use one oil for cylinders and bearings. Up to 25 brake horsepower per cylinder, a high-grade oil of 50 to 55 sec. Saybolt at 210 deg. F. is suitable, and for larger units, up to 100 brake horsepower per cylinder, an oil of 60 to 65 sec. at 210 deg. F. Diesel engines of higher horsepower require heavier oils for cylinder lubrication. Carbon contamination of the oil in the crankcase has to be guarded against, and for this reason many of the larger units are equipped with a continuous purification system, usually of the centrifugal type. Therefore, only first-grade oils should be used for the lubrication of Diesel engines.

Practice has demonstrated that definite economy in oil consumption is possible by a systematic method of oil distribution. In one instance, by providing each operator with an individual locker and a daily supply of oil, after seven months' trial a reduction was made of 20 per cent in the average cost of lubricants per unit of ore milled, as compared to the average cost during the preceding seven months' period.

In conclusion: Efficiency of application is equal in importance to selection of lubricants in controlling the economics of lubrication; or, as Charles Dickens put it: "The bearings of this observation lays in the application on it."

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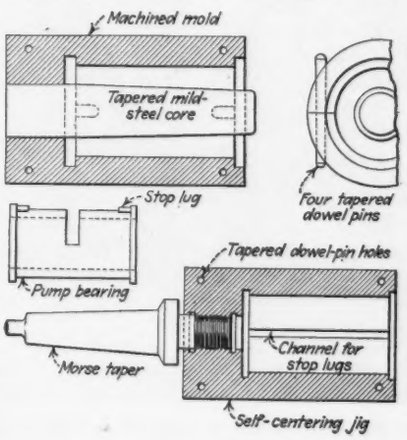
Casting and Turning Pump Bearings

MANUFACTURE of white-metal bearings, as illustrated in the accompanying cut, has materially reduced pump maintenance costs at the Texas Gulf Sulphur Company's plant at New Gulf, Tex., according to W. H. Kelly, master mechanic. Prior to its application, bearings were cast in a crude mold, and bored and turned in a lathe. Much time was wasted in setting and centering the cast bearing for the different working stages. By employing the carefully machined split mold, fitted with a mild-steel core and held together by four tapered pins, the numerous working stages are cut to two—that is, only the turning of the bore and the sawing out of the oil-ring channel are necessary. The dimensions of the mold bore, of course, are somewhat larger than those of the finished bearing, to allow for shrinkage. Boring of the bearing is accomplished with the self-centering jig shown in the illustration. The bearing rests securely in the split jig, adjusted by four tapered pins, which is attached to the lathe spindle by an inserted Morse taper.



Mine Development by Airplane

Newton Wakefield

THE USEFULNESS of the airplane in the mining industry has neither been appreciated nor exploited. This article purposes to describe the modern transport plane, its capabilities and limitations, and to show how it may be used by the mining industry in solving problems of preliminary exploration and transportation. The airplane has already been used in a limited way—in prospecting, mapping, and transportation — principally in Canada and South America; and in Mexico air transportation is fast replacing mule caravan. When one appreciates the fact that a transport plane of the Ford tri-motor type can carry a 3,000-lb. cargo at 100 miles per hour, many possibilities suggest themselves. During the summer of 1931 a large quantity of fire-fighting equipment, supplies, and many hundreds of men were transported by plane to remote districts for the Forest Service of the Northwest. The cost was less than surface transportation in many instances; with larger volumes it could be reduced to a figure considerably below it.

Many types of airplanes are on the market, from the fast single seater to the large multi-motored transport planes. Land planes, sea planes, and amphibians all have their particular use. Some are suited to transport operations and others to photographic work and reconnaissance. Choice of equipment depends upon the work to be done. However, the nature of work in conjunction with mining operations imposes limitations. The restricted area of landing fields inhibits the use of planes with a fast landing speed, and the keen competition of surface transportation makes impractical the use of high-speed equipment where payload is sacrificed for speed. Planes used in mining transportation work should have the following characteristics: slow-landing speed, high rate of climb, large payload, economy in operation, long cruising range, and sturdy construction. The Ford tri-motor plane seems to conform to these requirements better than any other transport plane built in the United States, and because of sturdy, all-metal construction and low cost of maintenance and operation it lends itself admirably to this type of work. It will land and take off of small fields with 3,000 lb. pay-load.

The general characteristics of a plane used in photographic work should be stability and performance at high altitudes, with particular attention given to the installation of the photographic equipment rather than its flying performance. Amphibions are rather impracticable and the auto-giro is useless in its present stage of development for mining work. Seaplanes can be used successfully for transport if the property is on or near a body of water.

Landing fields are not numerous in mountainous districts, but many suitable sites can be located from the air. Flat benches, sand bars, or meadows make good fields. The United States Forest Service is building landing fields at many points in the National Forests of the Northwest, to be used in transporting freight by plane to remote districts. Splendid fields are already developed by the Forest Service in the Selway, Idaho, and Flathead national forest. I have landed on all of these, and they could be used by mining companies in these districts as concentration points to receive supplies and materials for mine development work in the immediate vicinity. In other sections, where fields have not already been located, they can be built at small expense, usually by felling the trees on a bench and grading a suitable runway, or by smoothing out the rough spots in a meadow. The Forest Service figures the cost of this type of field at about the same cost as building a mile of trail, and no subsequent maintenance is necessary.

Fig. 1—Men and equipment ready to take off in a Ford tri-motored plane

The airplane can be economically and effectively used in transporting men, supplies, and equipment to prospects being developed in inaccessible country, far from truck road or railroad. By using air transportation, the expense of a road has been avoided, at least until such a time as the mine has been opened up enough to permit determination of the extent and value of the ore deposits. A landing field could be constructed near the prospect, or an already established Forest Patrol field might be used if one was in the area, and a contract made with an experienced aviation company to transport men and equipment for development work.

Fig. 2—Transport plane and supplies at Chamberlain Meadows field, Central Idaho. The distance from Spokane, 230 miles, is covered in two hours. Three days would be necessary if trucks and pack horses were used.

Another example of air transportation is that in which a new district, containing several prospects, is to be opened up. Here the airplane can be used to its greatest advantage in transporting men, equipment, and supplies. The field is first prepared in the center of the district, which will act as a concentration point for cargoes arriving by plane, and the material will then be redistributed from this field to the workings in the district. The volume of material transported thus will be so great that unit cost will be proportionately low, and the final cost of transportation far under that of any other method. In general, the unit cost of transportation varies inversely to the volume of material transported, other factors being equal. The airplane brings the isolated districts into direct communication with large towns and distribution points, and any district with a good landing field now enjoys the same advantages as camps did in the past that had roads connecting them with the outside world.

The Mamer Air Transport Company, of Spokane, Wash., has done considerable contract work for the United States Forest Service in transporting men and equipment into isolated districts in the Northwest. The Forest Service in District 1 was so well pleased with the results obtained that plans are being made for more extensive use of the airplane during the coming season, and many new fields are being prepared to accommodate the large transport ships. United States Forest District 4, embracing southern Idaho, Utah, and Nevada, is also including an extensive program of landing-field development in its next year's budget. All of these fields, available to the mining industry, will open up remote districts for exploration that have heretofore been neglected because of inaccessibility.

During periods of depression more people go into mining and farming than into any other industry. Many new mines will be discovered by prospectors, and the airplane will afford the larger companies the means of developing prospects quickly and economically. The airplane is also being used extensively in Canada and some parts of the United States to carry geologists and prospecting parties into isolated districts. The plan is usually to fly a geologist over the region to be prospected and let him study the general relation of outcrops and other geological features visible from the air. Aërial pictures may also be taken, and any interesting country mapped by building up a mosaic of the aërial photographs thus taken. The geologist finally reduces the entire area to small sections, which, from his observation and study, appear to have merit. A central landing field is then located, and prospectors, equipment, and supplies are flown to this point. The prospectors are assigned definite areas to cover. Every two weeks or so they return to the landing field with samples. These are then assayed by a portable assay outfit set up at the landing field, or flown to the nearest assay office. The field geologist is in this way able to keep a complete record of the work being done and can concentrate the prospectors in favorable sections. All work is under the control and supervision of the field geologist. Large areas can be thoroughly prospected in this way in the shortest time possible. Off-hand, this method of prospecting might seem to be expensive and rather impracticable; but, when the time element is appreciated, the cost is seen to be about the same as the old method of sending out a few men for a long period of time. Moreover, this type of work would not be attempted in an area that had not previously been studied as to geological formation and known mineralization.

Another effective way of coordinating the airplane with scientific prospecting, or geological survey, is to use a series of landing fields or a group of lakes as bases for supplies and distribution points for men. In this manner, one airplane can serve a large area in the same way that it can supply a small unit as described in the foregoing. Scientific prospecting is becoming more and more important, and each year the larger companies make substantial appropriations for this type of work. They not only reduce income tax thus, but are able effectively to provide for future operations by locating new properties.

Aside from being used as a vehicle of transportation, the airplane is particularly adaptable to reconnaissance and mapping. Petroleum geologists have used aërial mapping extensively in the United States and Latin America, to locate oil domes and to study surface geology. The results have been extremely successful and the cost is usually far below that of terrestrial survey. Aërial maps are complete in every detail, and give the engineer a pictorial representation of an area that would be impossible to get otherwise. They contain, in fact, such a wealth of detail that roads, power lines, tramways, and other surface developments may be laid out on the maps themselves. This is particularly helpful when the property is in some foreign country or isolated district, far from the engineering offices.

Aërial mosaic maps may be supplemented with stereoscopic views of important areas. These pictures give the observer the impression of looking at a miniature replica of the country photographed. All features stand out in perfect relief, and surface geology, timber surveys, and other studies can usually be made from the pictures alone. In hundreds of ways aërial pictures, aërial maps, and aërial reconnaissance can help the mining engineer. In the future the aërial camera will be as much a part of his equipment as the transit is today.

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Safety Glass for Emery Wheels

USE of goggles in operation of emery wheels is enforced in almost all machine shops, and goggles are generally placed so conveniently that no excuse may be offered for violation of the rule. For rough work this precaution is absolutely essential; for light work, however, such as sharpening small drills or small lathe tools, use of goggles may be dispensed with by equipping the hood of the wheel with a piece of window glass set in a frame, writes Charles Labbe, of Death Valley. The frame is made of sheet iron and is hinged so it may be turned over and out of the way for larger work. This arrangement permits easy inspection of the work and prevents any spark from flying into the face of the operator. The glass is quickly removed for cleaning and is easily replaced if broken.

Cost of Top-Slice Stoping

Morris J. Elsing

DURING 1929 the iron mines of the United States produced 15,900,000 short tons of ore by the top-slice method. Published costs of production show that 625,000 tons of this amount was produced at the surprisingly low rate of 97.5c. per short ton. When compared to the larger figure, the production in the United States from non-ferrous top-slice stopes is almost negligible. In Western United States in 1929, the method was used for producing about 8 per cent of the tonnage at the United Verde mine, Jerome, Ariz., and 3.8 per cent of the tonnage at the Old Dominion mine, at Globe, in the same State. In the past, the method has been used at the Copper Queen and at the Calumet & Arizona mines, at Bisbee, and in the Metcalf and Morenci districts in Arizona; at Bingham and Park City, Utah, and at Ely, Nev.

A large production at a remarkably low cost has come from the Miami mine, at Miami, Ariz. Considerable ore has been produced by the method at Nacozari, Sonora, Mexico, where during 1929 3.7 per cent of the tonnage came from this type of stopes. At Cananea, the method was installed by Col. Arthur S. Dwight in 1906 and has been constantly and extensively used since then.

Excepting the iron mines, no mines use the top-slice method of stoping exclusively. Complete costs are therefore difficult to obtain. Such a great difference exists between conditions obtaining in the iron mines and those in the non-ferrous metal mines that costs are not comparable and will, therefore, be considered separately.

Table I shows the detailed costs per ton at three mines in the Lake Superior iron region.

Central Western Mesabi—The ore mined by top-slicing at the mine referred to in Table I as on the central Western Mesabi lies in a flat bed of considerable extent and from 10 to 30 ft. thick. The ore is soft and granular, but the taconite roof is not strong enough to permit open-stope mining with pillars. Stopes are worked as rooms 10 ft. wide and 50 ft. long. Slices are 10 to 18 ft. thick, so that the ore is mined by either one or two slices. Unmounted jackhammers are used with auger steel. A cut 10 ft. wide, 5 ft. deep, and of the thickness of the slice, is drilled, blasted, mucked, and timbered in an 8-hr. shift. Stoping is done on contract. Mucking is done with scrapers, and a slide is used for filling 3-ton cars, which are trammed to the chutes. Timber sets are put in for each 5-ft. cut. Standard caps are 8 ft. long and the posts 10 ft. Boards, $\frac{5}{8}$ in. thick, are used as lagging, and if the ore is two slices thick, these boards, laid on poles, are used as flooring.

In 1928, this mine produced 232,500 short tons of ore at a cost of $1.036 per ton. Several reasons may be deduced for the low costs per ton. The ore is soft, which is equivalent to about 1 ton per foot of hole. The ground does not become excessively heavy, inasmuch as a large part of the ore is only one slice thick. Timber required is, therefore, much less than that necessary in the copper mines of the Southwest. Only 2.5 bd.ft. of timber per ton are used at this mine, compared with three or four times this amount in the Southwest. In addition to this advantage, abundant cheap timber is available. The total cost in 1928 was particularly low, because little or no development in waste was done that year.

Mine No. 2, Marquette Range—The ore at Mine No. 2 is a soft hematite which occurs in irregular scattered orebodies in ferruginous cherts and slates cut by dikes and sills of diorite. Top-slicing and sublevel stoping methods are used.

In the top-slicing method, two-compartment, cribbed, incline raises are driven to the top of the orebody. These are spaced 50 to 100 ft. apart. Radial openings, 10 ft. high and 10 ft. wide, are driven from a raise. These are timbered with 8-ft. round timbers and are lagged. Flooring consists of 3½-in. round poles 9¼ ft. long. On the first and second floors from the top of the orebody 8-ft. lagging is laid on these poles but not on the lower floors. Drilling is done with jackhammers and auger steel. The ore is mucked with scrapers directly into chutes.

All stoping is done by contract at 75c. to $1.60 per car of 4 long tons. This cost is from 16.6 to 35.5c. per short ton and includes labor, explosives, carbide, picks and shovels, lamps, and small accessories, which are furnished by the contractor. The company provides everything else. The contractor does his own blasting and timbering.

In 1928 a total of 266,700 short tons was produced by this method at a total cost of $1.216 per ton. This includes 22.3c. for development work. If this amount is deducted from the cost, the result compares closely to the cost of top-slicing on the Mesabi Range.

Mine No. 5, Marquette Range—At Mine No. 5 ore occurs in a synclinal trough. It is quite regular, being 100 ft. thick in the middle and thinning out at both sides. The ore is drilled by machines using auger steel. It breaks fine and is especially adapted to handling by scrapers. In most parts of the mine the wall rock and waste have good standing characteristics, and usually only a small amount of repair work is necessary.

Table I—Top-Slice Stoping Costs, Marquette and Mesabi Ranges
(On Basis of Short Tons)

	Central Western Mesabi	Mine No. 2 Marquette Range	Mine No. 5, Marquette Range	Average
Labor	$0.379	$0.329	$0.375	$0.361
Supervision	0.035	0.022	0.017	0.025
Explosives	0.053	0.067	0.048	0.056
Timber	0.125	0.062	0.070	0.086
Air, drills, incidentals	0.022	0.040	0.085	0.049
Power	0.021	0.042	0.007	0.023
Miscellaneous	0.013	0.067	0.056	0.045
Total stoping	$0.648	$0.629	$0.658	$0.645
Development	None	0.223	0.046	0.090
Transportation	0.114	0.123	0.187	0.140
General underground	0.223	0.172	0.081	0.158
Miscellaneous and surface	0.051	0.059	0.003	0.038
Total mining	$1.036	$1.206	$0.975	$1.073
Year	1928	1928	1929	
Reference (a)	I.C. 6325	I.C. 6179	I.C. 6380	
Timber				
Stope	.....	.....	.....	.....
Total	2.51 bd.ft.	0.50 lin.ft.	0.60 lin.ft.	0.84 0.37 lin.ft.
Powder per ton, Lb.				
Stope	.....	0.22	0.33	0.28
Total	0.35	0.43	0.36	0.38
Tons per man-shift				
Stope	.....	13.10	.....	.....
Underground	8.41	8.63	9.96	9.00
Total	8.13	.....	8.01	8.07

(a) U. S. Bureau of Mines Information Circular

This article is the sixth in a series on the cost of mining in the United States.

Table II—Top-Slice Stoping Costs per Ton; Western United States and Mexico

	Old Dominion, Globe, Ariz.	Coronado	Metcalf, Ariz.	Humboldt	Morenci, Ariz.	Calumet & Ariz., Bisbee, Ariz.		Miami, Miami, Ariz.	Veta Grande, Cananea, Mexico	Oversight, Cananea, Mexico	El Bordo, Pachuca, Mexico	Pilares, Sonora, Mexico	United Verde, Jerome, Ariz.
		Flat	(Incl.)	Flat	(Incl.)	Flat	(Incl.)						
Labor	$1.03	$0.81	$0.54	....		$0.63	$0.54	$0.35	$0.64	....	$0.45	....	....
Supervision	0.06	....	....	....		....	....	....	0.09	....	....	....	....
Explosives	0.10	....	....	....		0.07	0.04	0.04	0.15	....	0.07	....	....
Timber	0.30	....	....	....	15% less than flat	0.20	0.21	0.13	0.35	....	0.25	....	....
Air, drills, incidentals	0.12	....	....	....		0.10	0.10	....	0.13	....	....	....	....
Power	....	....	....	....		....	....	....	0.03	....	....	....	....
Miscellaneous	0.28	0.30	0.28	....		0.04	0.04	0.03	0.13	....	0.01	....	....
Total stoping	$1.89	$1.11	$0.82	....		$1.04	$0.93	$0.55	$1.52	$1.30	$0.78	$1.55	....
Development	....	....	....	....	....	....	....	0.14	0.32	0.34	....	....	....
Transportation	....	....	....	....	....	....	....	0.10	0.11	0.24	....	....	....
General underground	....	....	....	....	....	....	....	0.02	0.12	0.28	....	....	....
Miscellaneous and surface	....	....	....	....	....	....	....	0.07	0.12	0.14	....	....	....
Total mining	....	....	....	....	....	....	....	$0.88	$2.19	$2.30	....	....	....
Year	1930	Part 1916	Part 1917	1917	1919	1916	....	1916	1929	Half 1916	1918	1929	1929
Reference	Personal	A.I.M.E. Vol. 59		*E. & M. J.* May 27, 1922		(b)		A.I.M.E. Vol. 55	I.C. 6247	Personal	(a)	I.C. 6307	I.C. 6449
Timber board feet													
Stope	8.4			7.9	9.0						11.6	11.5	9.91
Total	....												
Powder, lb.													
Stope	0.49										0.18	0.29	0.71
Total	....										0.23		
Tons per man-shaft													
Stope	5.09	4.5	9.8	5.4	7.6						3.10	3.95	2.47

(a) A.I.M.E. Vol. 72. (b) A.I.M.E. Vol. 55.

Stoping is done from inclined cribbed raises run at 35-ft. intervals. Three narrow slices are taken out on each side of the raise and timbered with drift-set timbers. Poles 3 to 6 in. in diameter and 9.5 ft. long are used for flooring and are spaced 6 to 8 in. apart, being spiked to three crosspieces. Closer spacing of flooring is necessary in new ground. Ore is transported to the chute by electrically operated scrapers. Stoping is done by contract, the price being from 24.5c. to 40c. per short ton delivered to cars on the level. The price covers labor and explosives and small supplies but not timber.

Top-Slicing in Western United States and Mexico—All available cost data on mines in Western United States and Northern Mexico are presented in Table II.

The lowest top-slicing cost ever obtained in the Western United States was that of the Miami Copper Company, at which property 4,500,000 tons was mined between 1915 and 1918 by this method. A block 250 ft. square was taken out as a unit with a central supply raise and ore chutes at 50-ft. intervals. Stope timbers consisted of two 8-ft. posts with a 12-ft. cap or double sets with three 8-ft. posts and two 7-ft. caps. The costs per ton are shown in Table II. They are reported partly as an estimate, but were based on a large tonnage previously extracted. The development cost of 14c. per ton is made up of preliminary development, haulage development, and raise development.

Incline Top-Slicing—At the Coronado mine, Metcalf, at the Humboldt mine, Morenci, and at the Calumet & Arizona mine, Bisbee, horizontal top-slice stopes were changed to inclined stopes with a considerable increase in the tons per man-shift and a reduction in the direct stoping costs per ton. This reduction at the Coronado mine was 25 per cent; at the Humboldt and at the Calumet & Arizona the resulting costs were 15 and 10 per cent lower, respectively. The amount of timber required was slightly greater in the inclined stopes, but this was more than compensated by elimination of hand shoveling.

Mexico — At present, the horizontal method of top-slicing is in use at Cananea and Nacozari, in Sonora, Mexico. Costs are given in Table II for the Veta Grande mine, at Cananea. The ore at this mine is in a hard, siliceous gangue, which requires the use of considerable powder. The total cost does not include mine departmental expense, which includes superintendence, engineering, sampling, watchmen, time office, and related items.

Costs for the Oversight mine, Cananea, are shown for the last half of 1916, when 155,000 tons was mined. This ore was soft and some of it was exceedingly heavy ground.

At the El Bordo mine, in the Pachuca district, top-slicing was used in mining old fills. Interesting points about this operation are that from 5 to 8 per cent of the posts are recovered before the slice is shot down and that 2.5-in. floor boards were used instead of the more usual 2-in. flooring.

The two most representative costs of top-slicing in the Western United States are those of the Old Dominion and Veta Grande mines.

Theoretical Top-Slice Timber Costs—The theoretical amount of timber needed in top-slicing can be calculated rather accurately. Some choice of style or type of timbering may be exercised, but all slices require flooring when the ore is more than one slice thick. In the Western United States 2-in. plank are commonly used as flooring, whereas in the Iron Country the use of thinner hardwood floor boards or poles is the custom. Supporting timbers vary considerably. The three general types of support are by (1) drift sets, (2) square-sets, or (3) stulls with head blocks. The upright members used in these methods are spaced at different intervals, but never closer than at the corners of 5-ft. squares. When the distances are greater, less timber is required, but the 5-ft. interval is used in the following calculation, to make the amount sufficient to cover all operations. The type of timbering assumed in making this calculation is the stull-and-headboard method, when mining a block 50 by 50 and 11 ft. thick. Such a stope will require approximately the amounts of timber given in Table III.

Assuming that this ore has a specific gravity of 12.5 cu.ft. in place per ton of ore, one finds the block contains 2,200 tons. Therefore, the square timber used is 4.72 bd.ft. per ton and the round timber is 3.26 bd.ft. On the assumption that the square timber is worth 4c. per board foot, and the stulls $1 each, or 10c. per linear foot, the timber required amounts to 8 bd.ft. per ton and costs are $0.25 per ton of ore. These figures compare closely with those representing the present actual consumption at the Old Dominion mine.

Cost Analysis—Comparing costs obtaining in the Iron Country, a surprising similarity appears, not only of the

Table III—Timber Required in Top-Slicing a 50x50x11-Ft. Block With Stull and Headboard Support

Members	Board Feet Square Timber
Flooring, 250 2x12-in. plank 10 ft. long	5,000
Sills, 550 linear feet, 2x10-in.	917
Head blocks, 121 10x10-in., 2 ft. 6-in. long	2,521
Cribbed raise, 11 ft. of raise, 3x10 in. cribbing	990
Breakage, reinforcing, miscellaneous	950
	10,378
	Round Timber
121 stulls, 10-12 in. round, 10 ft. long, 1,210 linear feet	6,453
Breakage, reinforcing, miscellaneous	645
Total	7,098

total stoping costs, but with the exception of the development cost at Mine No. 2, of each individual item. The costs submitted for mines in the Western United States vary widely. With the exception of those for Miami, they are all much higher than those of the Iron Country. Three principal reasons for this are: (1) size and shape of orebodies; (2) physical characteristics of the ore and waste; and (3) cost of timber. These factors in the Iron Country favor low costs. In most instances the ore is strong enough to stand without timber but drills easily with machine augers, and the production per machine-shift is very high. The ore breaks with few boulders and is in an ideal condition for scraping. On the other hand, the waste hanging wall breaks in coarse blocks, and except for the first few floors permits use of a floor of small poles spaced at intervals of 6 to 8 in. Use of an inferior grade of timber purchased locally at a low price is therefore possible.

On the other hand, the mines in the Western United States have been developed mostly from comparatively small irregular orebodies. In most instances the ore must be drilled with machines and the usual steel, with a low production per drill-shift and a high powder cost per ton. The waste hanging wall is usually such that tight plank floors must be provided and for each slice. Even if poles were available the fine, oxidized gossan would sift between them and mix with the ore to such an extent as to prevent their use. Plank flooring at the mines usually costs approximately $30 per thousand board feet, and this is the reason that Western timber costs per ton are three to four times as high as those in the Iron Country.

Square-Setting vs. Top-Slicing—My experience with top-slicing dates back to 1910, and I have closely followed the method ever since. When I was superintendent of mines at Cananea I mined a variety of orebodies by top-slicing. They included both hard and soft ores, comparatively large orebodies, as well as veins. My experience indicates that wherever possible top-slicing should be used in preference to square-setting, because ore can be won at a considerably lower cost per ton. Conditions arise, of course, under which square-setting must be used to preserve valuable surface or to prevent the caving of areas in which orebodies or useful workings might occur. If these conditions do not exist, top-slicing is preferable by far, not only because of economy but also because the method is much safer.

One objection to top-slicing that has caused argument is whether or not sorting is possible. My own experience shows that sorting is not only possible in a horizontal stope, but that it can be economically done and with the loss of less ore than in a square-set stope. This can be accomplished by temporarily tacking plank on the outside of some of the stulls and throwing the waste back of them. The purpose of the plank is to prevent the blasting of ore on top of the sorted waste and losing it in the waste. The history of almost any square-set camp is replete with illustrations of the re-mining of square-set gobs. These gobs have been valuable primarily because of ore being lost in them. This has occurred because of hastily laid floors, which are not tight, with the result that ore sifts between the plank; floors may be broken and permit the ore to drop into the gob below, and through numerous other ways ore gets into the gob. Modern methods tend to prevent this loss, but in spite of them some ore is lost, which is almost an impossibility in top-slice stope.

Upon analyzing the direct costs of stoping, the following is found: Actual figures for stope development show that the cost by each method is practically the same. The methods of breaking ore by each method vary greatly, but the cost of drilling, blasting, and powder consumption are somewhat less for top-slicing. Possibly the mucking cost is slightly lower for a square-set stope than for the horizontal slice, but this is not true for incline-slice stopes. As a rule, scrapers are more effectively used in a top-slice stope than in a square-set stope and the cost of mucking can become closely parallel. Timbering costs in a top-slice stope are less than in the square-set. A really substantial saving in top-slicing comes from the use of about 20 per cent less timber, but the greatest saving comes from the fact that the method requires no filling. This cost as a minimum is 25c. per ton, and it often amounts to 50c. or even more. Another item of saving which is substantial but not susceptible of accurate calculation is the expense of maintaining and repairing drifts, crosscuts, and raises to make possible the filling of the square-set stope.

In Technical Publication No. 364 (1930) of the American Institute of Mining and Metallurgical Engineers, Howard Willey describes top-slicing at the Charcas unit of the American Smelting & Refining Company at San Luis Potosi, Mexico. He says: "For the conditions at Charcas, the method has many advantages over square-setting, the principal of which are: (1) greater safety for the workmen; (2) better total recovery and cleaner mining; (3) lower cost per ton mined."

The costs in Table IV show the saving per ton by using top-slice stoping instead of square-setting at Charcas.

Table IV—Saving Per Ton Owing to Use of Top-Slicing, Charcas Unit

	Mining Virgin Ore	Mining Old Workings
Labor	$0.106	$0.102
Explosives	0.008	0.011
Lumber and timber	0.411	0.270
Total saving by use of filled top-slice stoping	$0.525	$0.383

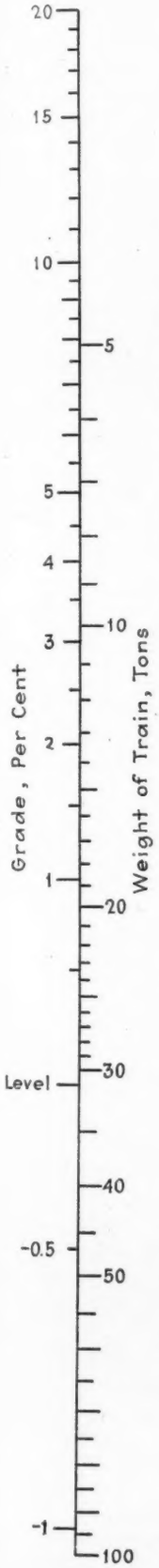
This saving is surprising, because each slice was filled with waste. Such procedure requires back-filling, which is usually the most expensive kind of filling.

I believe numerous orebodies exist in mines in the Western United States where, if top-slicing could replace square-setting, the cost per ton for stoping would be reduced 20 to 40 per cent, and this could be done with greater safety and more complete recovery of the ore. In general, the advantages of the method become more important as ground conditions become worse.

■ ■ ■

Assembling a headframe in Rhodesia

Battery-Locomotive Chart



Designed and Copyrighted by

Sydney C. Mifflen

THIS CHART is designed to show the watt-hours required at the battery of a storage-battery locomotive to move trains through varying distances over given grades. Allowance is made for ordinary mechanical efficiency and rolling friction.

PROCEDURE: A line joining the per cent of grade and the distance on their respective scales intersects the ungraduated scale at a point, about which the straight-edge is swung to align it and the point indicating the weight of the train, intersecting the watt-hour scale at the required value.

EXAMPLE: What should be the watt-hours at the battery of a 5-ton locomotive whose cycle of operations is to move a train of 12 tons of coal in four cars, each of 1½ tons' dead weight, through (a) 500 ft. on a 1 per cent falling grade, (b) 200 ft. on an 8 per cent falling grade, (c) 1,000 ft. on a 0.5 per cent rising grade, the empty trip to be returned over the same road?

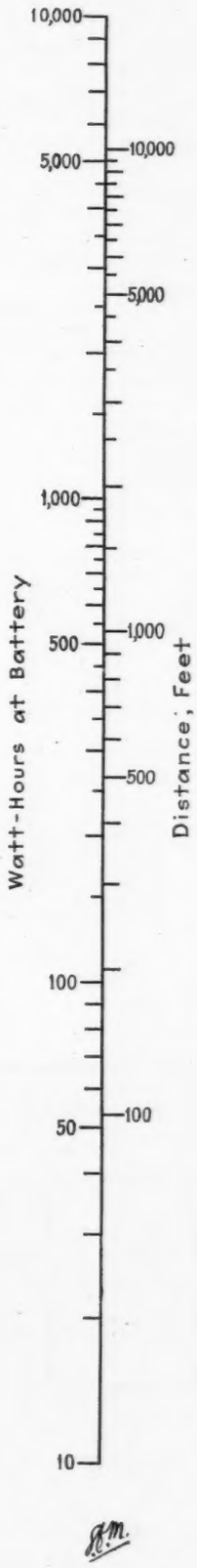
Each of the six operations must be solved separately, the total giving the watt-hours needed for the complete cycle. For the first operation:

Weight of train, loaded $= 5 + 12 + 4 \times 1\frac{1}{2} = 23$ tons
Grade $= -1$ per cent
Distance $= 500$ ft.

Join —1 and 500 on the *Grade* and *Distance* scales, respectively, intersecting the ungraduated scale at a point. Align this point with 23 on the *Weight of train* scale reading 65 watt-hours on the *Watt-hour* scale, as the required value.

Repeating the performance for the remaining five operations, the watt-hours required for the complete cycle is found to be as follows:

Train Loaded or Empty	Weight of Train, Tons	Grade, per Cent	Distance, Feet	Watt-hours
(1) Loaded	23	—1	500	65
(2) Loaded	23	—8	200	0
(3) Loaded	23	+0.5	1,000	520
(4) Empty	11	—0.5	1,000	125
(5) Empty	11	+8	200	240
(6) Empty	11	+1	500	155
			Total	1,105



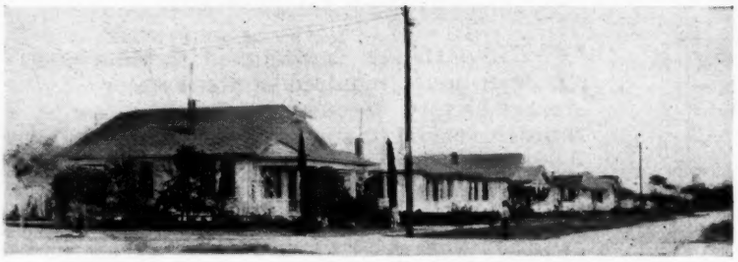
Employee Housing—II

A. H. Hubbell
Associate Editor

TYPES of employee housing used by companies operating in Northern Rhodesia, at Achotla, Guerrero, Mexico, and at Monterrey, Nuevo Leon, in the latter country, were described in an earlier issue, with suitable illustrations. The information thus presented is supplemented in this issue by similar data and illustrations, demonstrating various classes of employee housing used in several widely scattered regions such as the Gulf Coast of Texas; Pinar del Rio, Cuba; and the Upper Pecos Valley, in New Mexico. In coming issues, other regions will be considered.

Too late for inclusion in the preceding pages, the following additional information regarding the dwellings shown in Figs. 1 and 2 was received from the Roan Antelope management:

Timber used in the houses (Fig. 1) and in the Kator huts (Fig. 2) is imported Oregon pine, the objection to native timber being that it is subject to attacks of wood borers, is excessively hard, and warps badly. Window frames are made in the company's shop, and doors and sashes, also of Oregon pine, are purchased from a local mill.



Three-, four-, five-, and six-room houses of the general design shown in Figs. 6 and 7. Texas Gulf Sulphur Company, Newgulf, Tex.

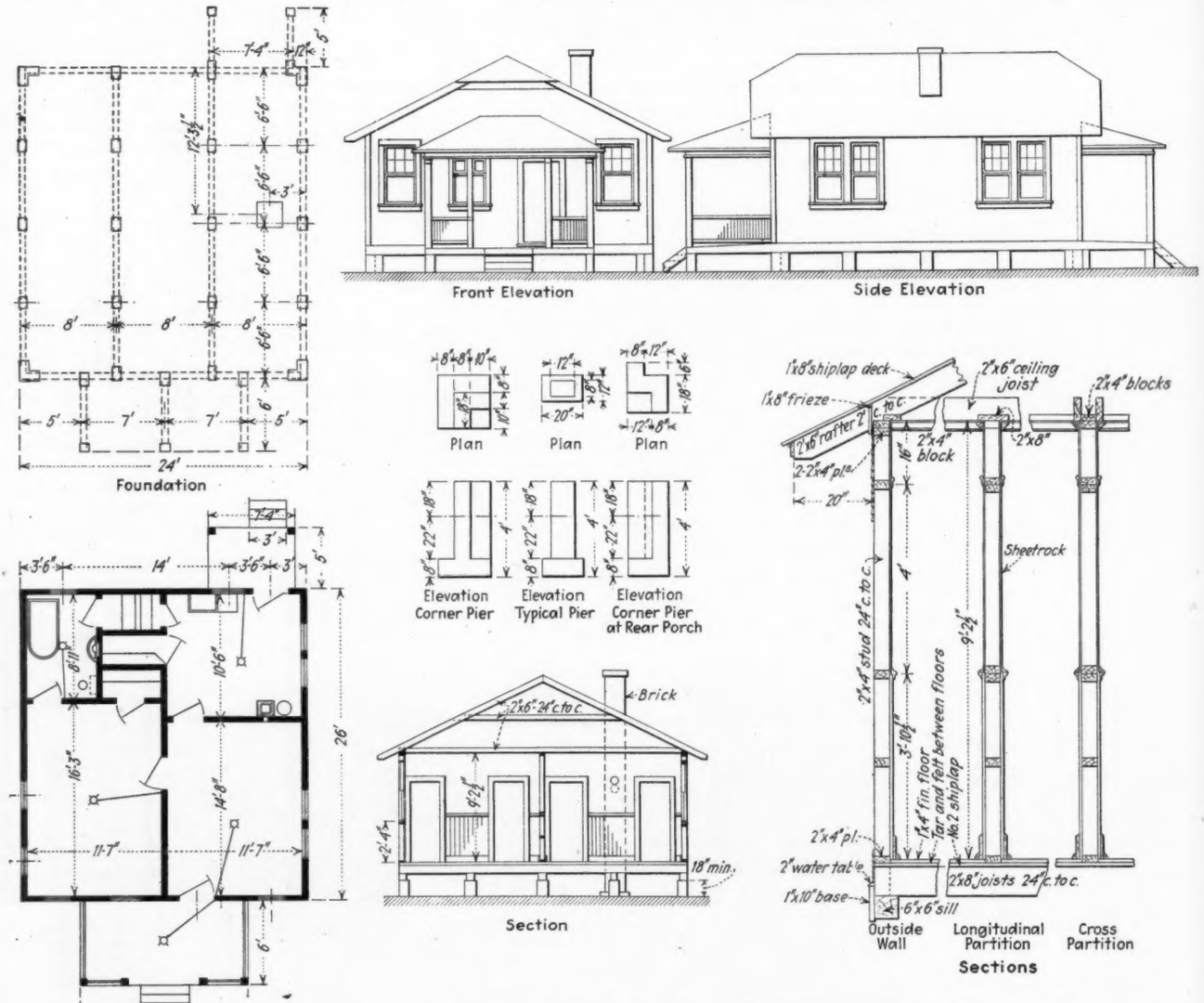


Fig. 6—Floor and foundation plans, elevations and construction details, three-room frame house, Texas Gulf Sulphur Company, Newgulf, Tex. See also Fig. 7

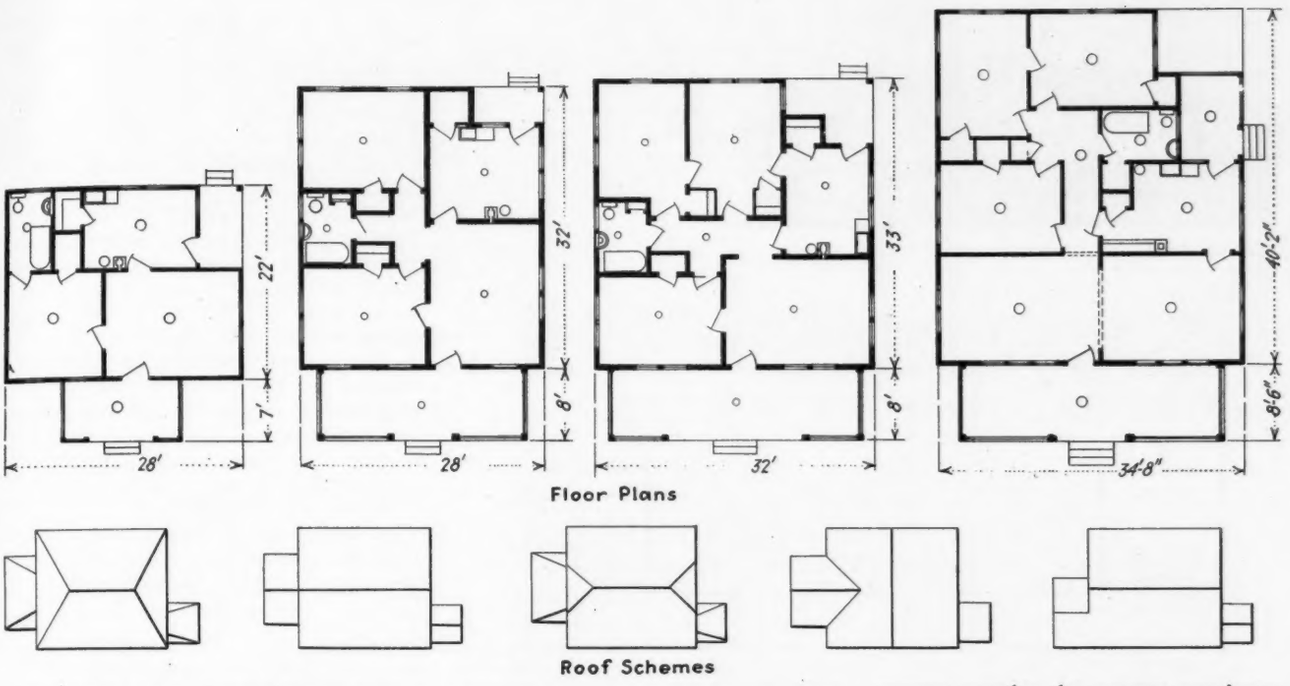


Fig. 7—Above, floor plans of three-, four-, five-, and six-room houses of Texas Gulf Sulphur Company, Newgulf, Tex. Save for layout and number of rooms, these houses are the same as the one shown in Fig. 6. Below, varied roof schemes used on houses shown in Figs. 6 and 7.

The brick used in the houses (Fig. 1) are kiln-burnt and are made by a local contractor, whose plant consists of a man-power pug mill and a steam-driven edge runner, or Chilean mill, used to prepare the ironstone, which is then mixed with clay in pits adjacent to the pug mill. The brick are then molded, stacked, and built into kilns by hand labor. The brick used in lining the Kator huts (Fig. 2) are 4.5x4.5x9 in. in size and are sun-dried, being made on the site by the contractor.

In the earlier stages of camp construction, brick dormitories were built for single Europeans. However, the isolated hut is almost universally used today in the region for single quarters, men greatly preferring it to dormitories because of the greater privacy. One employee, or sometimes two men, are accommodated in a hut. All occupants of these huts, as well as of the houses, are "Europeans." The origin of the term "Kator" is thought to be that it is the name of the inventor. The hut was used extensively in England during the War and was introduced into South Africa in 1920.

Housing of Texas Gulf Sulphur Company, Newgulf, Tex.—In Figs. 6 to 10 inclusive, as well as in several of the accompanying halftone pictures, are illustrated four classes of housing furnished by the Texas Gulf Sulphur Company for its employees at its Newgulf plant.

Newgulf is about 40 miles from the Gulf Coast. If December, January, and February be considered as the winter months, the average maximum temperature for the winters of 1929-1930 and 1930-1931 was 63.2 deg. F. The average minimum temperature for the same period was 43.2 deg. F. If June, July, August, and September be taken as the summer months, the average maximum temperatures for the summers of 1930 and 1931 was 92.1 deg. F., and the average minimum temperature 69.9 deg. F.

The average annual rainfall for the years 1927, '28, '29, and '30 was 37.59 in. Practically all of this was rain. Only in rare instances have snow and sleet fallen.

Five- and six-room houses built for executives at Newgulf by Texas Gulf Sulphur Company. See Fig. 8

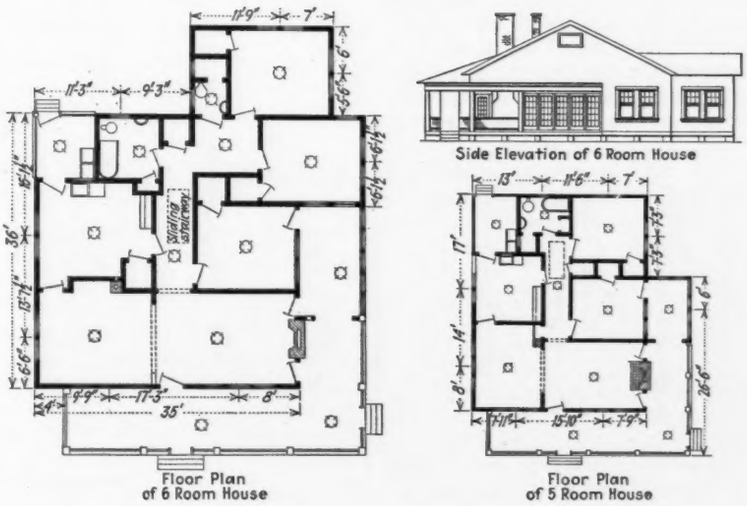


Fig. 8—Floor plans of five- and six-room houses, respectively built for executives at Newgulf, Tex. by the Texas Gulf company. Also an elevation of the six-room house.

Dormitory, Texas Gulf Sulphur Company, Newgulf, Tex. See Fig. 9

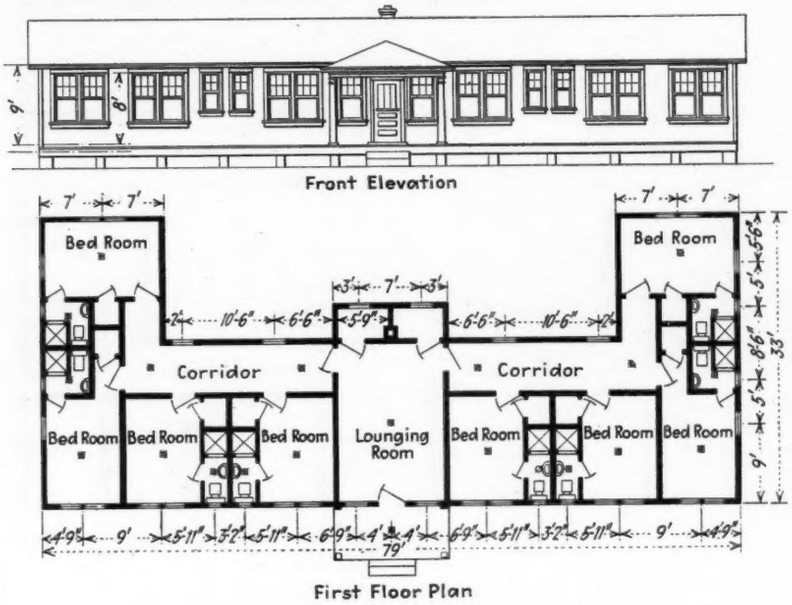


Fig. 9—Dormitory, Texas Gulf Sulphur Company, Newgulf, Tex.

In building its settlement at Newgulf, the Texas Gulf company followed the policy of using locally available materials, supplies, and labor as far as possible. The principal materials used in constructing the houses comprise concrete for the foundations, Southern longleaf yellow pine for the timber framing (6x6 in. No. 1 timbers), drop siding (No. 117 B & B, 1x6 in.) for the outside walls, rigid asbestos shingles for the roofing, and ½ in. painted sheetrock (U. S. Gypsum Company) for the inside walls.

Nothing out of the ordinary was used for purposes of insulation. For protection against the weather, 15-lb. felt was used underneath the siding. All floors were doubled, and, as a precaution against the spread of fire, asbestos roofs were specified in the design. No attempt was made to make the walls of the dwellings sound-proof or vermin-proof. The generally prevailing warm or mild weather made insulation against loss of heat unnecessary. To provide comfortable interiors in warm weather, provisions were made in the design of some of the houses, as for instance, those shown in Fig. 8, whereby the rooms opening on the screened porch could be thrown open into the porch by pushing the doors up into the attic enclosure overhead. Likewise in the bunk houses, shown in Fig. 10, part of the siding was hinged, so that it could be opened outward in warm weather, the opening being covered with gauze.

Streets in the settlement at Newgulf are laid out in blocks approximately 500 ft. long and 250 ft. apart, with a 10-ft. alley bisecting the square thus formed parallel to its length. Houses shown in Figs. 6 and 7 are placed six to the block, each dwelling being located on a lot 86 ft. wide and 120 ft. deep, on which also is a garage for the occupant's private use. The five- and six-room houses intended for executives, which are shown in Fig. 8, are placed five, instead of six, to the block. All houses are screened and shell sidewalks and driveways have been provided. In addition to the asbestos roofing, fire protection is supplied in conformity with the regulations of the State Fire Commission. Although in the white-family section (Figs. 6 and 7) only four sizes of houses are included, each group of sizes being built according to a similar plan, an external impression of a wide variation in design is nevertheless se-

Three-room bunk house, Texas Gulf Sulphur Company. See Fig. 10

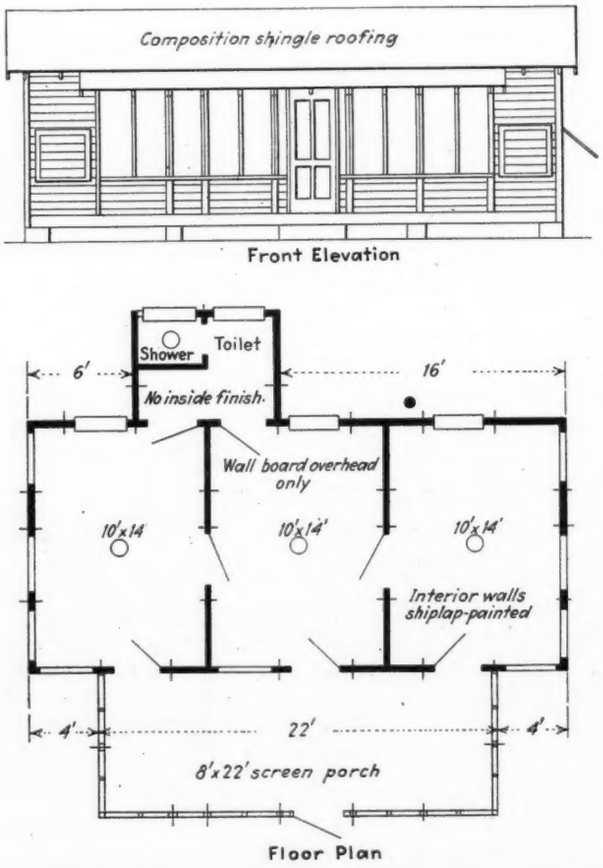


Fig. 10—Three-room bunkhouse, Texas Gulf Sulphur Company, Newgulf, Tex.

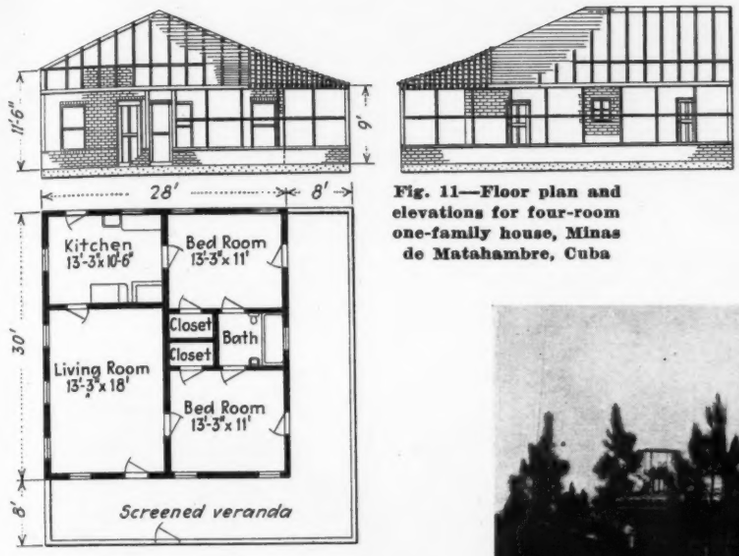


Fig. 11—Floor plan and elevations for four-room one-family house, Minas de Matahambre, Cuba

cured by using seven different types of roofs, five of which are shown in Fig. 7 in diagram, the effect of variety being heightened by the use of four different colors for the various roofs.

In addition to the data given on the drawings, one may also note that in the houses shown in Figs. 6 and 7 windows of the sash type are used, 28x30x1⅜ in. in dimensions, and having one light in the lower sash and six lights in the upper. The only exceptions are the windows in the bathroom and rear kitchen, which are 28x24x1⅜ in. in dimensions. In the kitchen closets of these houses a framed scuttle hole gives access to the attic space under the roof. The columns of the front porch are of the box type, 6x6 in. square.

All porches are screened, panel frames being used. They are likewise ceiled with 1¼-in. bevel edge strips. All outside windows and the door casings inside the porches are butt-joined to the siding.

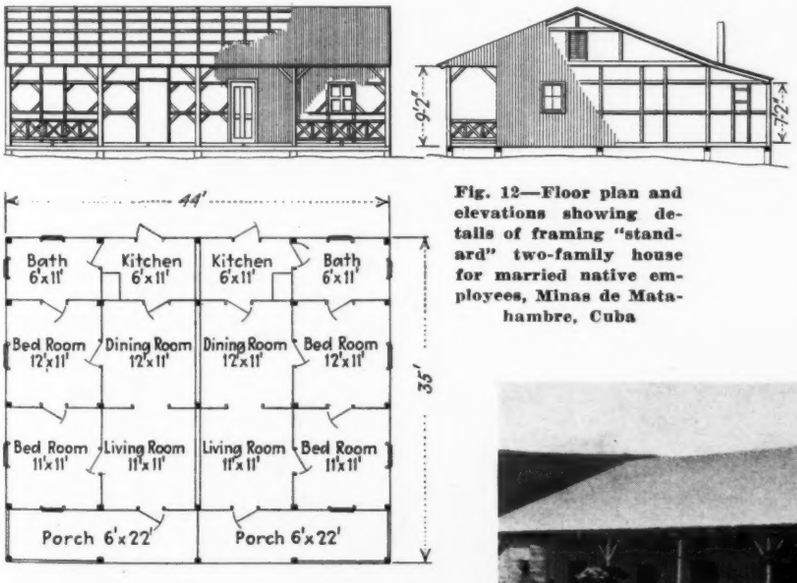


Fig. 12—Floor plan and elevations showing details of framing "standard" two-family house for married native employees, Minas de Matahambre, Cuba

houses, gas water-heaters, shower baths, and laundry trays, drainage from which is discharged through a modern sewer system to an improved septic tank.

Each house is equipped with electric light, wall switches being used in most instances. An ample supply of good water is provided. This is filtered and chlorinated, and tested in a laboratory, and is delivered to a 100,000-gal. elevated tank through an 8-in. cast-iron

Four-room one-family house, Minas de Matahambre, Cuba. Details are shown in Fig. 11

All houses are piped for and supplied with natural gas for heating. Arrangements are such that coal or oil-fired heaters may also be used if the occupant desires.

Bathrooms and kitchens are provided with modern equipment, this including porcelain-enameled tubs, lavatories, and low-down-tank flush closets, kitchen sinks, range boilers, and, in the larger main, from which the water falls under gravity head to the various houses through 4- and 6-in. cast-iron mains and galvanized iron services.

The bunk houses shown in Fig. 10 were the first houses built on the property. Material for these dwellings was supplied ready-cut by the mill, to facilitate construction at the outset.

The dwellings shown include all housing save the Mexican family quarters, of which no plans are available. These dwellings consist of tenant farm houses, which were moved in from various localities in the vicinity and fully reconditioned and painted.

Housing at Matahambre Mines, in Cuba—Four general types of houses are supplied for its employees by Minas de Matahambre, in Pinar del Rio, Cuba. These include the houses for members of the company's staff, shown in Fig. 11; houses for married native employees, shown in Fig. 12; and bunk houses for single native employees, shown in Fig.

Multiple-family house of design shown in Fig. 12, built for married native employees, Minas de Matahambre, Cuba

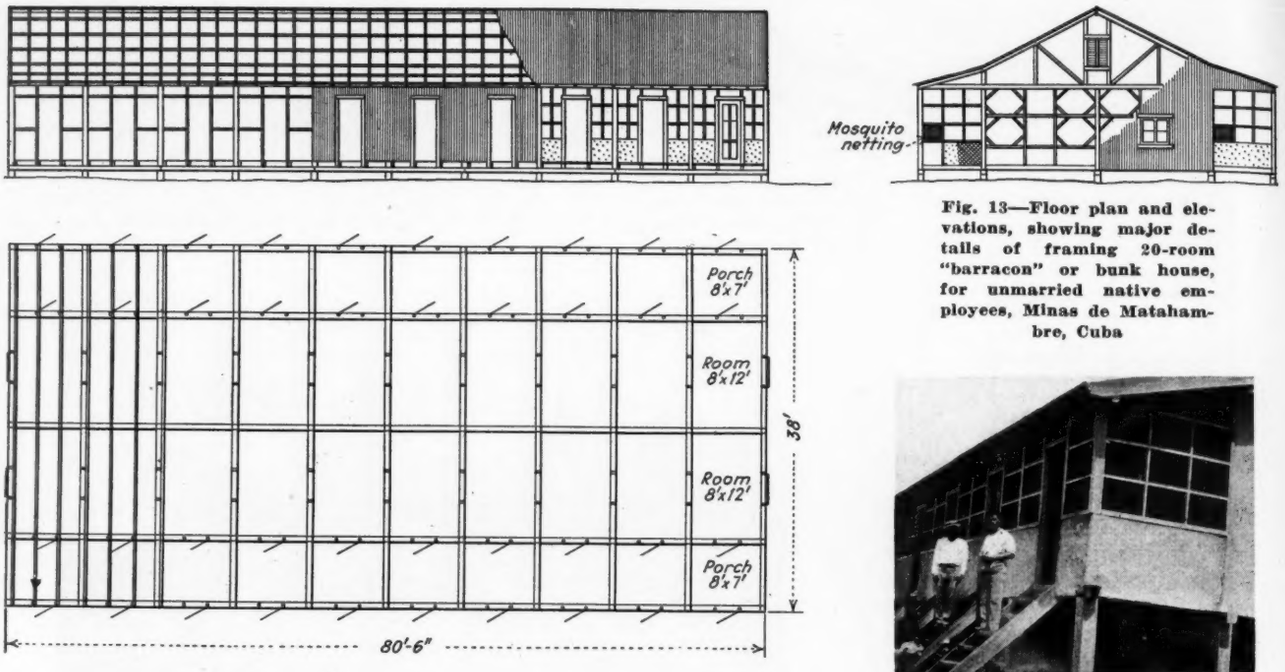


Fig. 13—Floor plan and elevations, showing major details of framing 20-room "barracon" or bunk house, for unmarried native employees, Minas de Matahambre, Cuba

One end of a twenty-room "barracon" built for single native employees, Minas de Matahambre, Cuba

13. These three types of dwellings are also illustrated in accompanying photographic reproductions. The fourth type, which is not illustrated, is a one-family house, of a kind now obsolete, used but no longer built for native employees.

The climate at Matahambre is equable and mild. The average summer temperature is 90 deg. F., and the average for the winter 75 deg. F. This simplifies construction of the housing considerably. Rain is relatively abundant. The average precipitation of the last seven years has been 65 in. annually. Most of it falls during the rainy reason, which lasts from June to November. During these months the rainfall varies from 4 to 16 in. per month, as compared with the dry season, when it varies from ½ in. to 4 in. monthly.

Prevailing climatic conditions make unnecessary any provision of insulation against heat or cold. Sufficient protection against vermin is obtained by the general use of concrete floors and avoidance of double walls and hidden corners.

All houses, as well as the barrack rooms shown in Fig. 13, are equipped with electric light. A filtered and chlorinated water supply is provided, the treatment being effected before the water is delivered to the main reservoir. All houses occupied by families are connected to this water-supply system. For employees living in the barracks (Fig. 13), water taps are provided at central points near by.

Staff and family houses are equipped with baths and toilets, which are connected to septic tanks. The barracks are constructed in groups, each group being served by a central bath and toilet house.

Substantial construction marks the houses shown in Fig. 11. The foundations are of concrete, the walls of brick plastered on the inside, and the roofs of tile. Interior walls are also of brick, plastered on each side. The average cost of one of them is approximately $3,000.

The company also has two staff houses built of wood. These have outside walls of drop siding, and are finished and lined inside with ½-in. tongue-and-grooved matched boards. Foundations and floors are of concrete and roofing is of corrugated iron.

The houses shown in Fig. 12, which are for native married employees, are in general intended for two families. The double house of this type is built at an average cost of approximately

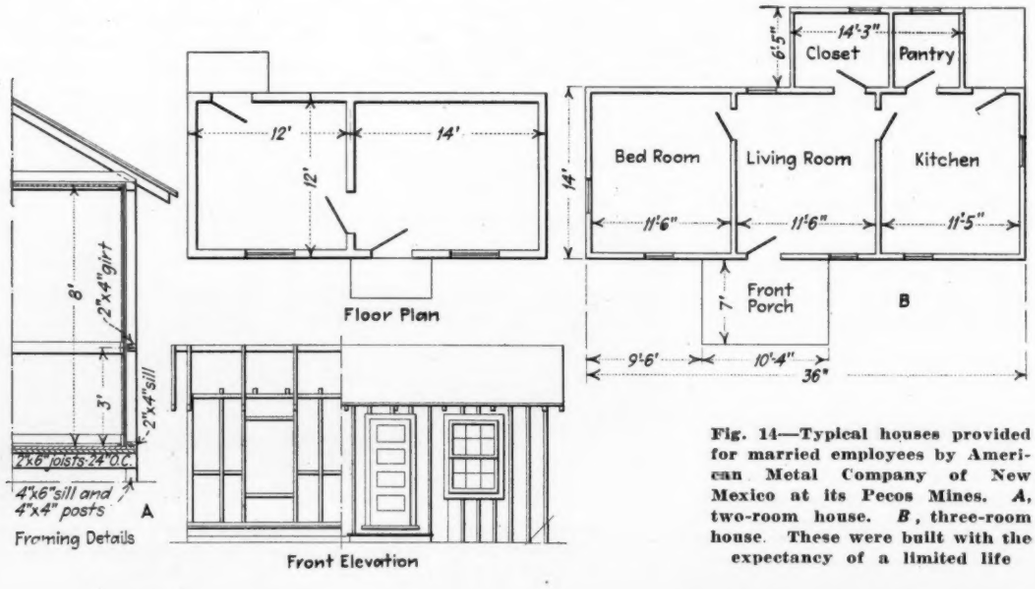


Fig. 14—Typical houses provided for married employees by American Metal Company of New Mexico at its Pecos Mines. *A*, two-room house. *B*, three-room house. These were built with the expectancy of a limited life

$1,500. It is carried on hardwood sills set on hardwood foundation posts. All of the corner posts are likewise of hardwood. The studding and flooring are of pine, and the siding and roofing of 24-gage iron sheeting. Partitions or inside walls are constructed of a single thickness of 1-in. ordinary pine boards with strips nailed over the joints.

Fig. 13 shows the so-called "barracon," or bunk house, for native employees. This is of the same construction as the houses occupied by native families, just described. Each will accommodate twenty men. Cost of construction is approximately $2,400 for each house.

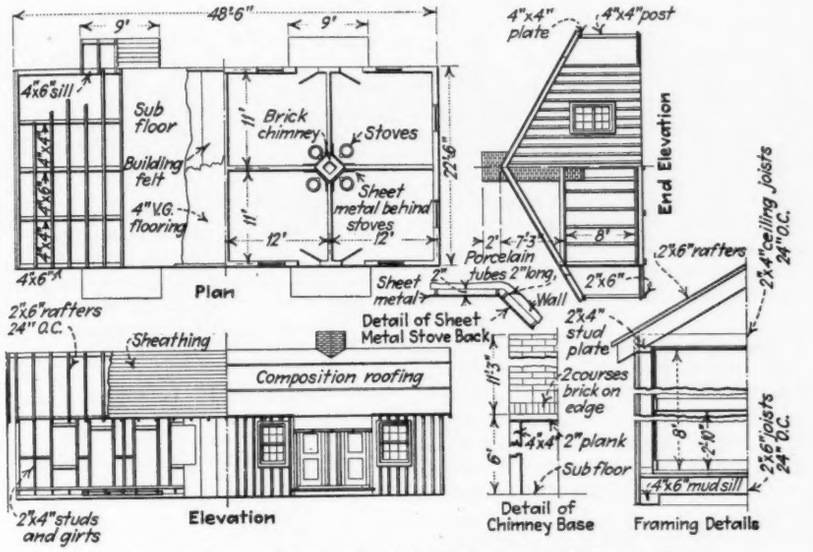


Fig. 15—Construction details of eight-room bunk house, Pecos Mines, New Mexico

Housing at the American Metal Company's Pecos Mine and Mill—The Pecos mines of the American Metal Company are in the upper Pecos Valley of New Mexico, about 30-odd miles east of Santa Fe. In general, the climate is mild, extremely hot weather being rare. During the winter the days are warm, but short periods occur when the temperature drops below zero at night. Water lines must be buried 3 ft. to avoid freezing. Frost first occurs about the middle of September, and continues during May and even sometimes in June. Average precipitation is about 20 in., about half of this being rain. Records show a total snowfall of 60 to 70 in. during the winter, the maximum at any time being approximately 1 ft.

The houses of the camps at mine and mill were built with the expectation of a very limited life, a fact which influenced their design. Fig. 14 shows a two-room and a three-room house, respectively. Fig. 15 shows an eight-room bunk house, and Fig. 16 shows the floor diagram of the house provided for the mill superintendent.

Houses of the type of construction used, according to the company, can be built in this locality at a cost of approximately $200 to $300 per room. The (1925-26) cost of five bunk houses at the mine was $1,700 each, including the small amount of equipment required, such as the small stoves and the double- and single-deck bunks shown in Fig. 15. Fifty-three two-room houses, such as those shown in Fig. 14, at *A*, were built for $518 each, and nine three-room houses, such as those at *B*, at $1,027 each. Seventeen additional three-room houses were built at a cost of $1,030 each. The eight-room house shown in Fig. 16 cost $4,235, completely furnished. This was the only house of this type built at the camp. Staff employees other than the mill superintendent occupy the old houses on the property at the time it was acquired. These are all of approximately the same type of construction.

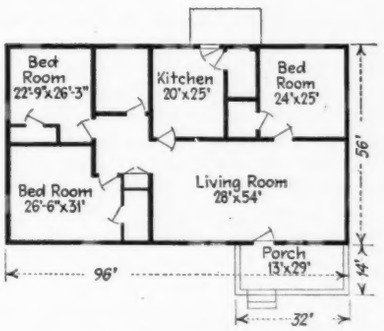


Fig. 16—Floor plan of mill superintendent's house, Pecos Mines

Details of framing and material are practically the same for all buildings used as dwellings, including the bunk houses. The houses have no cellars or masonry foundations, but are carried on mud sills laid directly on the ground, as shown in the details in Fig. 14*A*, and Fig. 15. On these sills rest the joists, which are either 2x6 in. or 2x8 in. and are laid on 2-ft. counters. The floors are of 3-in. native pine, over 1-in. diagonally laid sheathing, with 15-lb. roofing felt between. Porch floors are 6 in. lower than the main floors. Outside walls are framed of 2x4-in. studs, covered by 1-in. sheathing, with one layer of J M Housline between studs and sheathing. All studs are double at the corners. The sheathing is covered, in turn, with green or red Slate Cote roofing on the outside. On the inside of the studding of the outer walls ¼-in. wallboard is nailed, this forming the walls of the rooms. Inside walls, or partitions, are of 2x4-in. studs with ¼-in. wallboard on both sides. Ceilings are of ¼-in. wallboard nailed to 3x4-in. joists, set on 2-in. centers. The roof is built with a ¼ pitch and has 2x4-in. rafters with center ties, the rafters being covered with 1-in. sheathing, which in turn is covered with heavy pilot roofing.

Windows in the main rooms are of the double-sash, single-light type, with a 28x45-in. opening. Other windows are single sash, single light, with a 28x24-in. opening. Doors are of pine, those on the outside being 2 ft. 8 in. by 6 ft. 8 in., with five panels, and those on the inside 2 ft. 6 in. by 6 ft. 6 in., and four panels. All openings are screened. The chimney is of brick, in a single thickness, and is on the line of the partition between the kitchen and living room, so as to serve two stoves. All of the houses are equipped with Underwriters Standard electric wiring, the cost of which is included in the figures given for the cost of the houses.

According to the company, the type of construction described has proved satisfactory except for the roofing material. Instead of the composition roofing used, galvanized iron, it is thought, would have been better. Hail has often damaged the roofing used, so that quick repairs have been necessary.

(To be continued)

■

Mineral Products for Insulation

Heat-insulation materials used in building construction are commonly made from asbestos, gypsum, limestone, lead slag, as well as of wood and a variety of other substances of organic origin. They are classified, in a bulletin issued by the U. S. Department of Commerce, as follows: (1) Rigid, made in panels of various sizes and not to be confused with fabricated wallboards, which are usually thinner and denser; (2) semi-rigid, sometimes called "felts" and at times combined with metal lath; (3) flexible, consisting of loosely felted, fibrous mat, usually covered on both sides with paper or fabric; and (4) fill insulation, which is powdered, granulated, or shredded.

Depression by Cyanide in Flotation Circuits

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FOR SEVERAL YEARS the department of metallurgical research of the University of Utah, in cooperation with the U. S. Bureau of Mines, has been investigating flotation reagents and their effects on pure minerals.[1] The following is a study of the mechanism of the depressing effect of alkali cyanides.

The importance of this reagent is shown by the 1928 consumption of 2,195,155 lb. for 28,555,171 tons of ore.[2]

Conditions in a flotation cell are too complex to permit direct study of the reactions, although some products of the reactions have been identified.[3] The large mineral surface and the low concentration of some of the effective reagents suggest that the reactions involved are not as simple as those common in analytical chemistry.

As the effect of cyanides has been studied extensively,[4] only a few tests were made to correlate other data. When possible these consisted of a 4-min. conditioning period, followed by 5 min. collecting, unless complete recovery resulted in less time. A miniature cell of the type designed by J. F. Gates and L. K. Jacobsen[5] was used. Removal of cyanide was studied by agitating 50-gram samples for 10 min. in 100 c.c. of cyanide of known strength, and determining cyanide in the resulting solution colorimetrically as Prussian blue.

Trouble was caused by cloudy solutions. Agitation with water gave a clear-settling solution, but cyanide seemed to act as a dispersing or peptizing agent, giving a cloudy suspension, which interfered with color comparisons. With pyrite, color was imparted to the solution. The results, however, seem accurate to 2.5 m.g. per 100 c.c., or one part in 40,000. To throw further light on the mechanism of the reactions, a study was made of the solubility of metal xanthates in water and in cyanide.

Table I gives results of cyanide abstraction by pyrite of two sizes. The right-hand column shows roughly the water-soluble iron remaining after filtration. Removal of cyanide appears to be about proportional to soluble iron, and increases with the mineral surface.

For comparison, Table II shows the depressing effect of cyanide on pyrite activated with copper sulphate. The coarser material was easier depressed, but the cyanide required for depression of the fine is greater than would be expected if caused by soluble iron only.

Cyanide abstraction by sphalerite is shown in Table III. The same relation between the size and cyanide consumption is again evident. Amount of cyanide removed was, however, only about 60 per cent of that removed by pyrite. Correspondingly, the depressing effect of cyanide on sphalerite, as shown in Table IV, is less than on pyrite under the same conditions. Roughly the amount of cyanide required for complete depression in the two cases is inversely proportional to that abstracted by the two minerals.

Galena removes practically no cyanide from solution, as shown by Table V, and cyanide up to 1 lb. per ton has little or no depressing effect on galena, as shown in Table VI.

Solubility of Xanthates — Copper n-amyl xanthate, after 3 hr. agitation in distilled water, gave no trace of copper ion with potassium ferro-cyanide solution. Copper dissolved increased with sodium cyanide used, as shown in Table VII. With original cyanide concen-

Table I — Consumption of NaCN by 50 Grams of Pyrite Exposed for 10 Min. With Constant Agitation to 100 C.C. of Cyanide Solution

Mgs. NaCN Original	Mgs. NaCN Final	NaCN Consumed, Per Cent	Thiocyanate Test for Fe
Mineral Size: — 100 + 200 mesh			
0.0	0.0	...	Distinct red
2.5	None	100	Faint red
5.0	None	100	Very faint
12.5	—2	84	Colorless
25.0	—3.75	86	Colorless
Mineral Size: — 200 + 560 mesh			
0.0	0.0	...	Red
2.5	None	100	Distinct red
5.0	None	100	Faint red
12.5	None	100	Very faint
25.0	—2.5	90	Colorless

Table II—Flotation of 50 Grams of Pyrite Using 0.2 Lb. of Terpineol, 0.1 Lb. of $CuSO_4$ and 0.1 Lb. of Potassium Ethyl Xanthate per Ton of Pyrite

Mgs. NaCN	Lb. NaCN per Ton	Grams of Concentrate	Recovery Per Cent
Mineral Size: — 100 + 200 Mesh			
0.0	0	48.2	96.4
0.50	0.02	39.3	78.6
1.25	0.05	16.3	32.6
2.50	0.10	0.9	1.8
Mineral Size: — 200 + 560 Mesh			
0.0	0.0	48.8	97.6
2.5	0.1	40.5	81.0
5.0	0.2	20.3	40.6
12.5	0.5	0.4	0.8
25.0	1.0	0.0	....

Table III—Consumption of NaCN by 50-Gram Samples of Sphalerite

Mg. NaCN per 100-C.C. Original	Final	Consumed, Per Cent
Mineral Sizes: — 100 + 200 Mesh		
0.0	0	...
2.5	0	100
5.0	—2	60—
12.5	—7.5	60—
25.0	—12.5	50—
Mineral Size: — 200 + 560 Mesh		
0.0	0	...
2.5	0	100
5.0	—2	60—
12.5	—2.5	80—
25.0	—7.5	70—

Table IV—Flotation of 50-Gram Samples of Sphalerite Using 0.2 Lb. of Terpineol, 0.1 Lb. of $CuSO_4$, and 0.1 Lb. of Isoamyl Xanthate per Ton of Mineral

NaCN Used Mg.	Lb. per Ton	Concentrate, Grams	Recovery, Per Cent
Mineral Size: — 100 + 200 Mesh			
0	0	47.2	94.4
2.5	0.1	23.3	46.6
5.0	0.2	29.9	59.8
12.5	0.5	1.5	2.8
25.0	1.0	None	....
Mineral Size: — 200 + 560 Mesh			
0	0	46.3	92.6
2.5	0.1	44.8	89.6
5.0	0.2	43.0	86.0
12.5	0.5	44.0	88.0
25.0	1.0	10.0	20.0

Table V—Consumption of NaCN by Galena

NaCN per 100-C.C. Original	Final	Consumed
Mineral Size: — 65 + 100 Mesh		
2.5	2.5—	Trace
5.0	5	Trace
12.5	12.5—	Trace
25.0	25.0—	Trace
Mineral Size: — 200 + 560 Mesh		
2.5	2.5—	Trace
5.0	5.0	Trace
12.5	12.5—	Trace
12.0	25.0—	Trace

Table VI—Flotation of 50-Gram Samples of Galena Using 0.2 Lb. Terpineol and 0.1 Lb. Potassium Isoamyl Xanthate per Ton Mineral

NaCN Used Mgs.	Lb. per Ton	Concentrate, Grams	Recovery Per Cent
Mineral Size: — 65 + 100 Mesh			
0	0	47.6	95.2
2.5	.1	47.8	95.6
5.0	.2	47.6	95.2
12.5	.5	48.9	97.8
25.0	1.0	49.4	98.8
Mineral Size: — 200 + 560 Mesh			
0	0	48.3	96.6
2.5	.1	48.2	96.4
5.0	.2	47.9	95.8
12.5	.5	48.2	96.4
25.0	1.0	48.9	97.8

Table VII—Solubility of Xanthates in Cyanide Solutions—In Mols. per Liter

Salt	Conc. NaCN	Temp. Deg. C.	Conc. Metal Iron
Cupric n-Amyl Xanthate	0.00000	22	Not detectable with $K_4Fe(CN)_6$
	0.00051	22	0.000079
	0.00102	22	0.000079
	0.00255	22	0.000790
	0.00510	22	0.00158
Zinc n-Amyl Xanthate	0.00000	24	0.0002
	0.00051	24	0.0002
	0.00102	24	0.0008
	0.00255	24	0.0016
	0.00510	24	0.0020
Lead n-Amyl Xanthate	0.00000	21	0.00006
	0.00051	21	Not detectable with K_2CrO_4
	0.00102	21	
	0.00255	21	
	0.00510	21	
Cupric-Ethyl Xanthate	None	25	None
	0.00051	25	0.00012
	0.00102	25	0.00015
	0.00255	25	0.00099
	0.00510	25	0.00197

trations of 0.00255 to 0.0051 molal the ratio copper ion: cyanide ion was about 1:3. Zinc n-amyl xanthate is very slightly soluble in distilled water; the solubility is increased ten times in a 0.0051 molal sodium cyanide. Ratio of zinc ion: cyanide ion is somewhat less than 1:2. Lead n-amyl xanthate is soluble to the extent of 0.00006 mol per liter in distilled water; in cyanide solution no lead could be detected by either chromate or sulphide.

Table VIII gives the results of cyanide-abstraction tests with chalcopyrite. As with the other minerals, the finer sizes abstract more than the coarser. The accuracy of these tests is impaired somewhat by discoloration of the solution. Table IX shows that cyanide up to 1 lb. per ton does not inhibit flotation of chalcopyrite.

Preliminary tests of the pyrite used gave water-soluble iron in amounts varying with the exposed surface. Cyanide removes this iron, and no cyanide-ion concentration was detected until iron was completely removed. The brownish-violet color produced by agitation of pyrite with cyanide was probably caused by formation of ferricyanides, perhaps with some ferrocyanides.[6] A possible reaction under the conditions is formation of $Fe_3(CN)_6$; after filtration neither ferric nor ferrous ions gave a precipitate with the solution. Ferricyanides probably predominate over ferrocyanides, though a coating of either should have practically the same effect on flotation of pyrite. If the coating results from adsorption of ions or salts of ferro- or ferricyanide—a reasonable assumption—the former should depress more effectively.

Coating of pyrite with ferri- or ferrocyanide ions would be harmful in two respects. First, by replacing wholely, or in part, the metallic luster of the mineral by a film more easily wetted by water than by air.[7] Second, adsorption of complex cyanide ions would tend to neutralize electric surface charges, or to present a negatively charged surface. Callow[8] states that the floatable minerals are positively charged in the cell; Bull[9] measuring the charges on galena and on quartz found the latter having a negative charge. That air bubbles take on a negative charge as given by Coehn's[10] rule is generally known; McBain and Williams[11] actually measured this charge. By destroying positive charges, the attractive force between mineral and bubble would thus be removed.

Compared with pyrite, sphalerite was found to remove less cyanide, and to be correspondingly less affected by the depressing effect of cyanide, though no exact relation was observed. Cyanide may be removed by adsorption as well as by reaction, and two different minerals would probably not have the same capacity to adsorb salt or ions from solution. Zinc sulphide is so insoluble that noticeable formation of zinc cyanide should not be expected. However, caused probably by zinc sulphate from surface oxidation, a white suspension occurred when sphalerite was agitated with dilute sodium cyanide. Zinc cyanide will dissolve in excess sodium cyanide, and presence of the $Zn(CN)_4$ ion has been noted by A. M. Gaudin, Haynes, and Haas.[12]

Stevens,[13] in his patent, ascribes the depressing effect of cyanide to its solvent action on the mineral itself. R. E. Head and E. L. Tucker,[4] photographing films produced on certain sulphides by cyanide, lime, and zinc sulphate, though in higher concentrations than used in flotation practice, showed that the depressing effects are in the same order as the densities of the films. From Table VII the solvent action of cyanide appears largely to affect the metallic xanthates, preventing any considerable xanthate formation on the mineral surfaces at the usual concentrations. A. M. Gaudin,[14] in his work on copper-free sphalerite, obtained results which led him to conclude that cyanide dissolves the activating film of copper sulphide, and that unactivated sphalerite is not normally very floatable. The sphalerite used in this work contained 0.12 per cent copper, and hence his results could not be checked.

From a study of the solubility of metallic xanthates, the essential mechanism of depression by cyanide seems to be to prevent formation of metallic xanthate on the mineral surface. This idea is supported by experiments in which sphalerite was activated by the addition of 1 lb. of lead nitrate per ton. A 94 per cent recovery was obtained with 0.2 lb. of terpineol and 0.1 lb. of potassium ethyl xanthate; the same recovery resulted when 1 lb. of sodium cyanide was added.

Galena, as noted, does not react with cyanide at ordinary flotation concentrations, nor does cyanide have a depressing effect on galena. Lead n-amyl xanthate was found to be soluble in distilled water, to the extent of 0.00006 mol per liter; in cyanide up to 0.0051 molal, no trace of lead was shown by chromate or sulphide after 3 hr. agitation. This lack of solvent effect on lead compounds, together with the ineffectiveness of cyanide in the flotation cell, is at least negative evidence in favor of the theory that it depresses through a solvent action.

Reagents reacting chemically with galena, such as dichromates, may also act as depressants. Adsorption of gangue on sulphides is also suggested as preventing the formation of a film by the collecting agent.

Chalcopyrite, although removing less cyanide than pyrite, is not depressed by cyanide up to 1 lb. per ton. If the mineral were floatable only through the effect of a surface film of collector, depression should be expected with a sufficient cyanide concentration. Chalcopyrite is quite readily floated by terpineol alone, and hence may float even without a xanthate film.

The theories offered as explanation of the phenomena of depression are necessarily the results of the popular metal-

Table VIII—Removal of Cyanide by 50 Grams of Chalcopyrite From 100 C.C. of Solution

Conc. of NaCN Original	Conc. of NaCN Final	Removed, Per Cent
Mineral Size: — 65 + 100 Mesh		
2.5	0	100
5.0	0	100
12.5	5—	60+
25.0	7.5—	70+
Mineral Size: — 100 + 150 Mesh		
2.5	0	100
5.0	0	100
12.5	2.5—	80+
25.0	5—	80+

Table IX—Flotation of 50 Grams of Chalcopyrite Using 0.2 Lb. Terpineol and 0.02 Lb. Potassium Isoamyl Xanthate per Ton of Mineral

Mg. NaCN Used	Recovery, Per Cent
Mineral Size: — 65 + 100 Mesh	
0	100
2.5	100
5.0	100
12.5	97
25.0	97
Mineral Size: — 100 + 150 Mesh	
0	100
2.5	100
5.0	100
12.5	100
25.0	100

lurgical conception of the mechanism of flotation. As flotation is regarded as a surface phenomenon, most theories postulate a surface change. Thus have been evolved the theories of gangue adsorption, surface alteration by acids or oxidizing or reducing agents, and adsorption of precipitates formed by the depressant. The suggestion is here offered that cyanide depresses sphalerite and pyrite by preventing the formation of a xanthate coating on the mineral surface. This may come about either by the formation of a precipitate, a weak salt, or a complex ion.

At very low concentrations, copper solutions are colored yellow by addition of xanthates; this is the basis for colorimetric tests for copper. At greater concentrations a precipitate forms. Qualitatively, this yellow color is easily destroyed by adding a few drops of 0.05 molal cyanide, even in the presence of nearly ten times as much potassium ethyl xanthate. This color, as would be expected, may be restored by adding more copper sulphate. The color changes, which are practically instantaneous, show that the rate of solution of metallic xanthates in cyanides is sufficiently rapid to decompose a xanthate film from the surface of sphalerite in the time of contact usually prevailing in a flotation cell.

The mechanism of depression can be completely defined only when the causes of flotation are understood and evaluated. A review of the work done on collecting agents is convincing, that with the xanthates and other soluble collectors the formation of a compound on the mineral surface is the chief cause in promoting flotation. From the data presented one may reasonably conclude that depression by cyanide is primarily the result of their solvent action on collecting films formed by the collecting agent on the mineral surface.

Some other effects of cyanides which probably contribute to the depressing action on certain sulphides are: (1) With zinc sulphate, zinc cyanide is formed and may be precipitated on the mineral surface; (2) in the presence of pyrite, cyanide forms ferro- and ferricyanides which may be adsorbed; (3) complex cyanides and cyanide ions tend to change the polarity of the change adsorbed on the sulphide surface, (4) by hydrolysis, cyanide affects the alkalinity of the pulp.

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Copper Determination by the Fluoride-Iodide Method

Henry N. Thomson

A MODIFICATION of the iodide method for the titration of copper in presence of iron has been described by Mott, Fraser, Reese, Crompton, and others. Interference from iron is prevented by addition of a fluoride to form the stable compound Fe_2F_6, which does not react with potassium iodide. This formation of a non-dissociating iron fluoride, according to Fraser, was observed in 1898 by R. W. Roberts.

The method is rapid and gives little chance for manipulative errors, being made from start to finish in one flask. When some years ago its use was suggested to two large copper producers, one stated that the method was not employed, on account of impermanence of end point. Admittance was made, however, that it might not have had a fair trial. The other company, which sells concentrates to a smelter, experienced trouble with the end point, but the results obtained were lower than those reported by the buyer. This precluded the use of the method. Investigation showed that the difficulty lay in the determination of the copper value of the solution used in titration. Mott describes standardization on copper foil with no iron or fluoride present. Fraser and Reese do not describe this step. Whether or not they realized the importance of the presence of these elements cannot be deduced from their articles. The iodide method is based on quantitative liberation of iodine by copper compounds. Standardization with copper, and with copper plus iron and fluoride, might be expected to give identical results. Unfortunately, this is not the fact. Several determinations gave the following figures with thoroughly mixed and aged thiosulphate: Copper alone, 1 c.c. = 0.00251 gram Cu; copper, iron, and fluoride, 1 c.c. = 0.00254 gram Cu. This makes a difference of 0.3 per cent on a sample containing 25 per cent copper.

Use of varying amounts of copper in standardization was found to make no difference in the titration value of the thiosulphate. Iron content should run over 40 mg. Below this the solution value drops appreciably, until at about 5 mg. it is the same as that obtained with copper alone. Variation in iron from 40 to 200 mg. had no effect. Although not mentioned in the writings referred to, this difference in value has been known to some analysts for several years. Lord and Demorest suggest standardization with iron and fluoride present. In describing this method, as used at a large copper concentrator, the statement was made: "The standard of hypo is slightly higher than for the ordinary iodide, so it is advisable to standardize against a standard pulp when using the fluoride modification."

The procedure recommended, which agrees in general with that outlined by Crompton, is as follows: A standard solution is prepared by dissolving 9.8 grams sodium thiosulphate in 200 c.c. water and diluting to one liter; 1 c.c. = 0.0025 gram Cu. For high-grade samples a solution twice this strength may be used. As indicator is used 2 grams prepared starch, mixed with 30 c.c. cold water, poured into 100 c.c. boiling water, and heated for a few minutes.

A sample of 0.5 to 2.0 grams is decomposed in a "copper" flask with 5 c.c. water and 8-10 c.c. nitric-chlorate mixture, keeping the temperature below the melting point of sulphur until decomposition is complete. The solution is not permitted to evaporate below 8 c.c. About 30 c.c. hot water is added, and the solution boiled briskly for 5 min. to insure removal of nitrogen oxides and chlorine. Dilute (1:1) ammonia is added slowly to the hot solution from a burette, until a slight precipitate of iron hydroxide remains, taking care not

to make the solution alkaline; 3 c.c. glacial acetic acid is added, followed by 3 grams sodium fluoride, shaking the flask until the solution is clear. Three grams of potassium iodide in small crystals is added after cooling, and the sample titrated in the regular manner.

To standardize the solution, three pieces of c.p. copper foil are weighed accurately (50 to 100 mg. is a suitable weight for each sample); 0.5 to 1.0 gram of ferrous ammonium sulphate is added; the sample dissolved in water and nitric-chlorate mixture, and then the procedure as described is followed.

Notes

Amount of sample used should contain between 5 and 150 mg. copper. With low-grade material, liberation of iodine is slow; with high-grade samples, the large amount of cuprous iodide formed gives a faint tinge of brownish purple, which may be mistaken for the last traces of the starch-iodide color.

If the sample contains less than 40 mg. iron, enough ferrous ammonium sulphate to make up the deficiency is added. Presence of much iron oxide may prevent complete solution of copper in nitric-chlorate mixture. In such a case the sample is evaporated to dryness with 10 c.c. hydrochloric acid, in a beaker instead of in a flask, keeping the temperature below the boiling point during the evaporation. When the sample is dry, water is added and nitric-chlorate mixture, whereupon the regular procedure is followed.

Lead does not interfere chemically, but forms a yellowish iodide. This color is easily distinguished from free iodine, as it does not react with starch.

Investigation of effects of presence of arsenic and manganese gave the following results: In the procedure given, arsenic and antimony will be in the pentavalent state. As the solution is not evaporated to sulphuric acid fumes, no danger of reduction to the trivalent state by particles of free sulphur exists. Park, showing a slight interference from pentavalent arsenic, outlines a method using potassium biphthalate to prevent this. Experimental work with varying amounts of copper and arsenious acid—at least 40 mg. of iron being present—showed no interference from arsenic when the method described is followed.

Unless present in large amounts, manganese does not interfere if the following points are strictly observed: The solution in the flask must not boil until after the addition of 30 c.c. of water. Alkalinity of solution must be avoided. If brown manganese oxide should separate during the nitric-chlorate treatment, it is filtered off, the filtrate is evaporated to 30 c.c., and the regular procedure followed.

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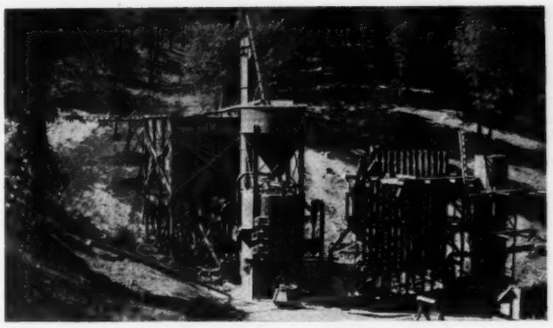
A California Quicksilver Plant



General view of the Nichols Herreshoff quicksilver plant. At the left is the tramming level serving the bin. Trommel and crusher are below the bin discharge. The steel-housed bucket elevator is behind the furnace. To the right of the furnace is the dust collector and hopper; on the extreme right, the condensers and washer towers.

G. J. Young
Associate Editor

REDUCTION PLANTS for quicksilver ores have been considerably improved since the days of the Scott furnace and the earlier shaft furnaces. Mechanically operated furnaces are now standard in quicksilver plants. One of the latest installations in California makes use of the Nichols Herreshoff furnace and certain features of design that are proving satisfactory in operation. The plant was installed by the Bumsted Mining Company three miles south of Middletown, Calif. The quicksilver holdings, known as the Great Western, were first opened in 1873, and produced steadily until 1909, after which a few leasers operated. Total yield was about 100,000 flasks. W. F. Detert acquired the property, and when he died the Bumsted company took it over from his estate.

Detert started the reopening of the mine before his death. E. J. Bumsted continued the mining work, and recently decided to equip the property with a reduction plant. The equipment was installed and the building completed early in December last.

Ore is trammed and dumped over a grizzly, 6-in. bar spacing, into an 80-ton wooden ore bin, and is delivered from the bin by a feeder to a 3x6-ft. trommel (1-in. holes), the oversize being discharged into a No. 2 Wheeling crusher set to crush to ¾ in. Undersize and crusher products are spouted to a chain-bucket elevator and delivered to a 20-ton steel ore bin above the Herreshoff furnace. A steel shelf receives the ore from the ore-bin spout. Adjustable feed knives scrape off the ore on the shelf on each half revolution of the roaster shaft.

The furnace is 10 ft. in diameter by 9 ft. 6 in. shell height; and, including the ore bin, is 34 ft. high; it is of four-hearth construction, the lower two hearths being used for combustion. Two oil burners, supplied with fuel oil under 125-ft. head and air at 2-lb. pressure, and placed at the side of the furnace, discharge into refractory-lined steel burner boxes, each serving one of the two lower hearths. Each of the burner boxes is arranged to receive hot secondary air for combustion, the air coming from the discharge of the cooling air in the rabbling arms.

Air for combustion is furnished by Root blower driven by a 1½-hp. motor. The air-cooled rabble arms and central shafts receive air from a small fan operated by a 1½-hp. motor. Rabble speed is 1 r.p.m., obtained by a speed reducer and belt-connected 1½-hp. motor. Rabble blades upon the two firing hearths are of Pyrocast metal, and of ordinary cast iron on the upper hearths.

The Herreshoff, equipped with working doors, is provided with well-designed sealing devices. The bottom outlet of the lowest hearth discharges the calcine into a bin, the bottom of which is fitted with a slide gate and lever placed directly over the calcine track. Calcine is trammed in a 16-cu.ft. car to a waste dump.

Gases of combustion and the quicksilver vapor pass through a 6-in. Sirocco dust collector of the cyclone type, where a small amount of dust is removed and delivered to a dust hopper, fitted with blast gates top and bottom, the upper gate being open except when discharging the hopper, the gases passing to a central discharge and being carried by a 9-in. diameter pipe to an exhaust fan of special design (4,100 r.p.m., 2-hp. motor), which discharges them into an equalizing chamber 2½ ft. in diameter and 8 ft. in height, including the hopper bottom. Two pipes receive the gases from the equalizing chamber, and divide them between two condenser runs, each consisting of ten cast-iron pipes in series, each 8 in. in diameter, 18 ft. long and with walls ½ in. thick.

The pipes are joined by return bends

Per-Ton Costs and Production Data, Bumsted Mining Company

	Oct., 1931	Nov., 1931	Dec., 1931	Jan., 1932	Feb., 1932	March 1932
Mining:						
Labor	$0.66	$1.47	$1.22	$1.19	$1.23	$1.44
Supplies	.....	0.07	0.08	0.08	0.05	0.31
Total mining	$0.66	$1.54	$1.30	$1.27	$1.28	$1.75
Furnacing:						
Labor	$1.56	$0.86	$1.05	$0.93	$0.75	$0.74
Supplies	0.06	0.15	0.03	0.10	0.10	0.03
Maintenance	0.36	0.29	0.12	0.03	0.03	0.11
Fuel oil	0.44	0.65	0.46	0.68	0.45	0.56
Power	0.17	0.13	0.16	0.14	0.14	0.13
Empty flasks	0.16	0.14	0.10	0.07	0.06	0.17
Total furnacing	$2.75	$2.22	$1.92	$1.95	$1.53	$1.74
General:						
Management	$0.89	$0.55	$0.66	$0.53	$0.47	$0.46
Audit and legal	0.15	0.05	.....	0.09	0.05	0.08
Insurance, general	0.36	.....	.....	.....	0.04	.....
Insurance, compensation	.....	0.57	.....	.....	0.55	.....
Taxes	.....	0.28	.....	.....	.....	0.05
Office and assaying	0.15	0.02	0.02	0.03	0.02	0.02
Wires and 'phone	0.02	0.01	0.01	0.02	0.02	0.02
Lights	0.06	0.02	0.04	0.03	0.02	0.02
Auto and truck	0.08	0.06	0.29	0.08	0.02	0.03
Road work	0.34	.....	0.21	0.06	0.03	.....
Miscellaneous	0.17	0.02	0.02	0.04	0.70	0.06
Total general	$2.22	$1.58	$1.25	$0.88	$1.92	$0.74
Total operating costs	$5.63	$5.34	$4.47	$4.10	$4.73	$4.23
Tons treated	336	542	446	562	641	658
Flasks quicksilver produced	64	76	70	80	60	70
Cost per flask	$29.60	$38.10	$28.35	$28.81	$50.57	$39.73
Mercury recovery per ton, lb	14.5	10.6	11.9	10.8	7.1	8.1

Selling costs ($3.60 per flask) and depreciation not included.

Actual average selling cost per flask: Hauling to railroad (18 miles), 17c.; Freight to San Francisco, 27c.; Cartage to steamer, 12c.; Marine insurance, 8c.; Ocean freight to New York, 47c.; Cartage in New York, 18c.; Brokerage in San Francisco, $1; Brokerage in New York, $1.35; Total selling cost, $3.64. October costs are not strictly accurate, as the plant was just starting at that time and a system of accounts had not been established.

with caps at the top and connect with hopper bottom Y's at the bottom, the bottom of the Y discharging into quicksilver trays protected by water seals. All of the trays are submerged in water contained in a redwood trough. From each condenser run the gases pass into a wooden-stave gas washer 5 ft. in diameter by 20 ft. high and thence to a redwood stack 18 in. i.d. and 29 ft. 8 in. high, and to the atmosphere. The conical bottom of the washer contains water, and the piping of the condenser is arranged to discharge the gases through this water at a fraction of an inch of head before going to the upper portion of the washer. The gas-washer discharge is received in a settling tank, in which are baffles and an overflow.

Bumsted states that almost all of the quicksilver is caught in the first three pots of each condenser run, the last pot receiving less than 2 per cent of the recovery. The quicksilver in the pots is almost all metal, remarkably free from dust, soot, or mud, but is finely divided. It runs together upon the application of heat. For this purpose David Thomson has devised a heating table receiving its heat from the hot air delivered by the rabbles. What residue remains after coalescing the quicksilver is returned to the furnace. No lime or other reagent is used in the final recovery.

Motor equipment is as follows: 20-hp., operating feeder, trommel and crusher; 3-hp., elevator; 2-hp., exhaust fan and condenser runs; 1½-hp., rabbles; 1½-hp., Root blower; 1½-hp., fan for cooling rabbles; total motor horsepower, 29½. Furnace capacity is 20 tons. The ore contains considerable surface and combined moisture. Fuel oil is 10.2 gal. per ton calcined (72 gal. per flask). Labor, mine, five men at $4 per shift; three furnacemen at $4 per shift; crusher man at $4 per shift; total labor, nine. A 2-mile power transmission line connects with a main line. Power costs for the operation of the plant approximate $90 per month.

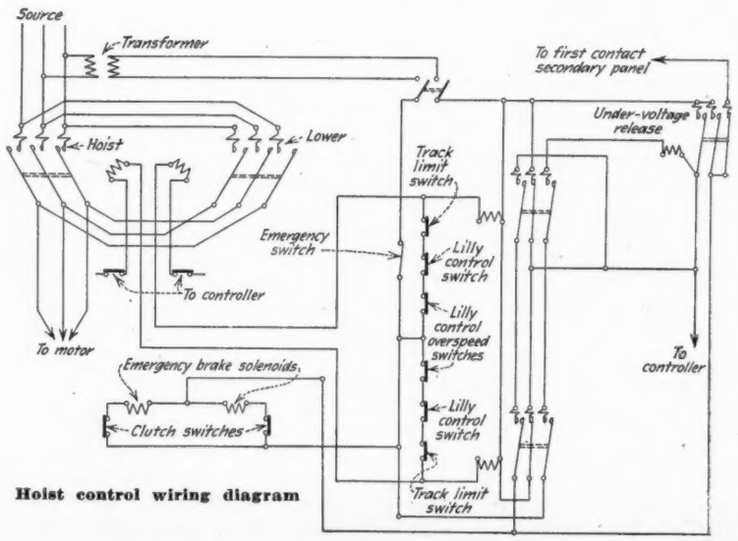
The operating data for November were given by Mr. Bumsted as follows: Tons mined, 544; tons furnaced, 542; quicksilver recovered, 76 flasks; fuel oil consumed, 5,500 gal. The plant was designed by G. E. Connolly, chief engineer of the Pacific Foundry Company, of San Francisco, and the equipment was supplied by the same company. Mining is done by hand. The plant is simple and efficient.

■ ■ ■

Improved Form of Safety Switch for Hoists

WHAT have been designated as "Mo-Speed" relay switches have been designed by C. L. Moore, chief electrician at the Bingham mines of U. S. Smelting, Refining & Mining Company, in Utah, as added safety features of the electric hoists in use at that property. As originally installed, the principal safety features were two sets of Lilly controllers, consisting of overwind, underwind, and overspeed switches, and an overspeed warning bell; also two track limit switches, one in each compartment or shaft. One overwind, the opposite underwind, one track limit, and one overspeed switch are connected in series, controlling each direction of travel. After operation of any of these safety appliances for cutting out the power and applying the brakes, the hoistman formerly could step on a reset button and then continue operations, perhaps repeating his first mistake and causing serious damage.

Mr. Moore substitutes the Mo-Speed relay switch for the reset button, Lilly control main switch, and the back-out switch, compelling the operator to reverse the direction of hoist travel when normal hoisting limits have been reached.



Hoist control wiring diagram

MINE SKIPS

Lucien Eaton

WHEN a decision has been reached as to the kind of shaft to be sunk—its location, orientation, inclination, size, shape, arrangement, and lining—the next question is the hoisting equipment to be used.

If the shaft is a very flat incline with a slope less than 30 deg., two methods of hoisting suggest themselves. The first is to hoist the ore directly in cars, as is done with coal in slope mines, and the second is to use skips. The first method, formerly popular, has in most operations been superseded by skip hoisting. Delays in dumping and in switching the trips between the slope and the levels, and the personal hazards of this switching and of riding the trips, have combined to put the method into disfavor. For the few mines of slight depth it has advantages. One outstanding example of a variation of this method is seen at the Premier diamond mine, Pretoria, Transvaal. This great pit has reached a depth of about 600 ft., and produces daily 16,000 tons of "blue ground," hoisted by endless rope up a flat incline in 1-ton cars. The limit of the present incline in depth has been almost reached, and another incline has been started, which will reach well below the present bottom of the pit, and make a large tonnage available; but the same capacity apparently could have been obtained at less expense by sinking a vertical shaft.

If the shaft is inclined at an angle greater than 30 deg., modern practice admits only the use of skips. If the shaft is vertical, the ore may be hoisted in skips or in cars on cages. The latter system, still in favor in a few districts, was considered to be the best practice 35 years ago. At that time skips were used almost exclusively in inclined shafts, and the increase in efficiency effected by the skips was sometimes the deciding factor in the kind of shaft selected. However, with the development of the Kimberley skip, and the system of rapid loading and hoisting used by the diamond mines at Kimberley, all this was changed, and hoisting with skips in balance in vertical shafts became standard practice.

Although skips are the best means of hoisting ore in inclined shafts, they possess disadvantages in shafts with slopes between 30 and 50 deg. Difficulty is experienced in filling a long, narrow skip when it lies at an inclination not much greater than the angle of rest of broken ore. If the skip is long, the ore tends to accumulate along the bottom or front, and to leave vacant spaces along the back, especially when it enters the skip in a direction more or less normal to the track. To reduce this tendency and to increase the speed of loading, loading pockets should be designed so that the ore enters the skip in a direction approximately parallel with the track. In steep inclines, with a slope of 60 deg. or more from the horizontal, trouble of this sort does not occur, and in very flat inclines the back of the skip is omitted, and the skip becomes to all intents and purposes a car.

Many special types of skips have been designed for use in inclined shafts, but these will not be discussed, the standard types only being considered. One of the best designs for shafts of low inclination is that used in the iron mines at Birmingham, Ala. It is large, the standard capacity being 10 tons, and has no back, but it has a door in front, held in place by the bail. These skips operate at high speeds at inclinations of 15 to 30 deg. Although the bail is made of heavy-section wrought iron, a few failures have occurred, and the usual practice in this district is to supplement the bail with a loop of heavy wire rope, which passes endwise completely around the skip, and is attached independently to the hoisting rope. This skip is shown in Fig. 23, taken from Peele's "Mining Engineers' Handbook." Derailments are decreased by the use of springs in axle-boxes, and by a system of three-point suspension, which prevents unevenness in the track from lifting one wheel off the rail.

Large skips are used extensively in the Michigan copper district. Here the rails are customarily laid on stringers;

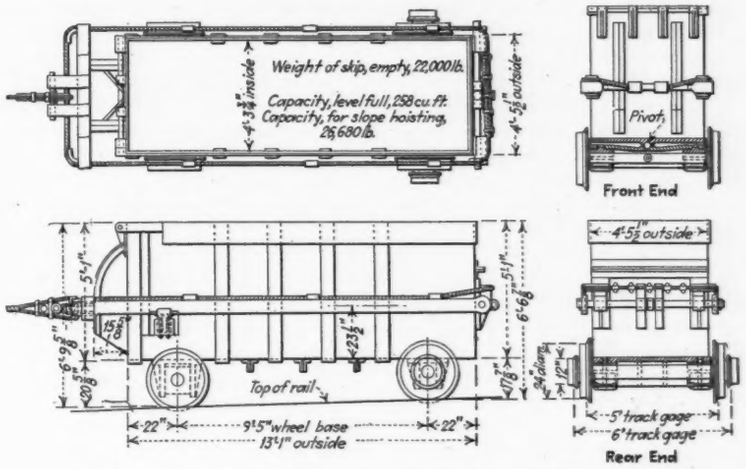


Fig. 23—Skip with three-point suspension, for flat slopes

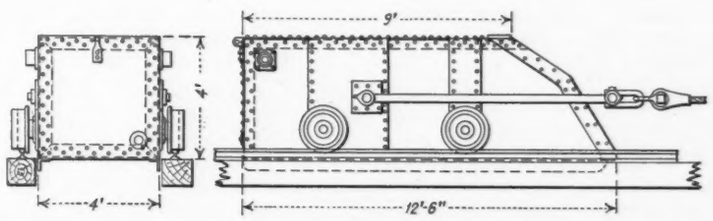


Fig. 24—Eight-ton skip, weighing 4½ tons, Hancock No. 2 shaft, Quincy mine, Michigan

and, in order to increase the size and stability of the skip, the wheels are put on the sides of the body, and not on an axle that passes underneath, and the body is dropped low enough to be between the rails or even between the stringers. An example of this type of skip is shown in Fig. 24, also taken from Peele's "Handbook." The most common type of skip for an inclined shaft is shown in Fig. 25. Skips of this type are simple to build and to repair, and operate satisfactorily under ordinary conditions.

Certain rules, dictated by experience, should be followed in designing a skip for an inclined shaft. The body of the skip is made of boiler plate, held together inside by angle irons. Lining plates are needed on the bottom and

This is one of a series of articles on "Mine Equipment."

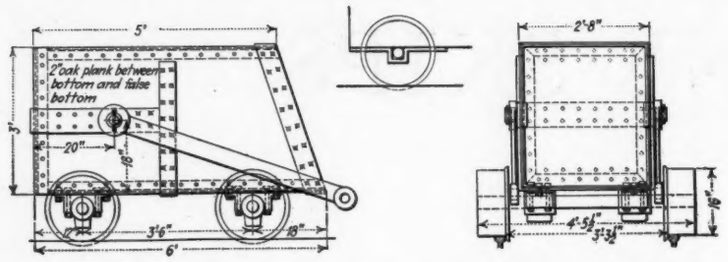


Fig. 25—Simple type of skip, of 2 tons' capacity, for an inclined shaft

rear end only. Heavy reinforcing straps should be put around the mouth and around the middle, and these straps and the bail should be made of a good quality of wrought or Swedish iron. The bail should be attached to the sides a little below their center line at a point about one-third of the length of the skip forward of the rear end. This will prevent overturning if the skip is hoisted too far in the dump.

The distance between the flanges of the wheels should be ½ in. less than the gage of the track, and the wheelbase should be, if possible, somewhat longer than the track gage. Wheels of alloy steel or manganese steel may be either tight or loose on the axles, the latter being preferred. The tread of the rear wheels should be about twice that of the front wheels. Bearings should be bronze-bushed and self-oiling. On account of the heavy shocks encountered, the use of roller bearings is not common. Axles may be made of soft steel, but an alloy steel may be well worth the small difference in cost.

Inclined skips are usually dumped by turning the track to a horizontal position, and at the same time continuing other rails with a slightly wider gage above the turning point, keeping the inclination the same as or higher than that of the track below the dump. The front wheels follow the horizontal track, and the rear wheels follow the outside rails. Outside guiding strips are necessary to keep the rear wheels in alignment, and for this reason the hubs should not extend beyond the outside edge of the tread. A flange in the middle of the tread of the rear wheel is sometimes used; but it takes up necessary room and has other disadvantages.

Heavy rails should be used in skip tracks in inclined shafts, 30 lb. being the minimum and 50 or 60 lb. being standard for skips of two to five tons' capacity. The rails may be spiked directly to the footwall plates of the shaft, to cross ties, if the shaft is not timbered with sets, or to stringers. Concrete stringers were tried in the Michigan Copper Country, but they were too rigid, and caused too much breakage on the skips, and are not now in favor. Some cushioning under the rails is necessary, and this is admirably provided by wooden stringers. Each rail should be notched or drilled in one or two places, so that the spikes may prevent creep. Joints should be made with angle bars.

In shafts steeper than 40 deg. the custom is to use backrunners over the rails to keep the skip on the track; but, if the design and precautions used in the Michigan Copper Country are followed, back runners may be dispensed with in shafts as steep as 70 deg.

One of the large items of expense in inclined shafts has been the maintenance of rollers for the hoisting rope. These, usually made of wood, had plain bearings, and required lubrication every day. A new type, however, having a mid-section of manganese steel, grease reservoirs at the ends, and Timken or ball bearings, has reduced roller expense to a minimum.

Skips for vertical shafts may be of two types—the overturning, or Kimberley type, and the bottom-dumping type. Bottom-dumping skips have some advantages in handling ore that runs freely, but this type of skip is almost unknown, except in coal mines, and the consensus of opinion seems to be that, for hoisting ore, its disadvantages outweigh its advantages.

The Kimberley skip consists of a frame or bail running on guides, and a box, open at the top, fastened to the bail by a hinge, which is far enough from the center line to insure the stability of the box. Mounted on the sides of the box near the upper end are two rollers, which engage in a track at the dump and cause the skip body to overturn as it is hoisted, and to return to an upright position as it is lowered. Examples of Kimberley skips are shown in Figs. 26, 27, and 28. Fig. 26 shows an 8-ton skip used at Kimberley. This was later changed to an 11-ton skip. Fig. 27 shows a 9-ton skip used by Montreal Mining, for hoisting iron ore in northern Wisconsin. Fig. 28 shows the 10-ton skip of Roan Antelope Copper, in Northern Rhodesia. These are all large skips, selected as examples of modern construction. Smaller skips would be similar in design.

The Kimberley skip shown in Fig. 26 is larger at the top than at the bottom, and the bottom corners are rounded. The first makes for ease in dumping, but not for stability; the second helps to prevent accumulations of ore packed in the corners, but makes repairs more difficult. The Montreal skip, shown in Fig. 27, has square corners, and is so designed that it can be built or repaired at an ordinary mine blacksmith shop. The Roan Antelope skip has, at the top, dumping horns of a design different from those of the other skips. They are carried back as part of the side plates, which are cut off at the top on an arc of a circle, which has the dump axle as a center. A corresponding plate is fastened to the bail on each side and across the back, so that the skip is inclosed across the back and most of the way along the sides. This arrangement, which helps to prevent spill in loading, was copied from the skips of Tennessee Copper, at Copper

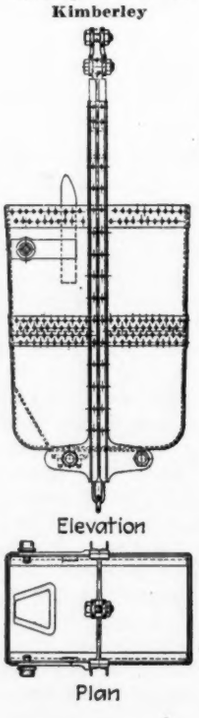


Fig. 26 — A Kimberley-type skip, of 8 tons' capacity, actually used at Kimberley

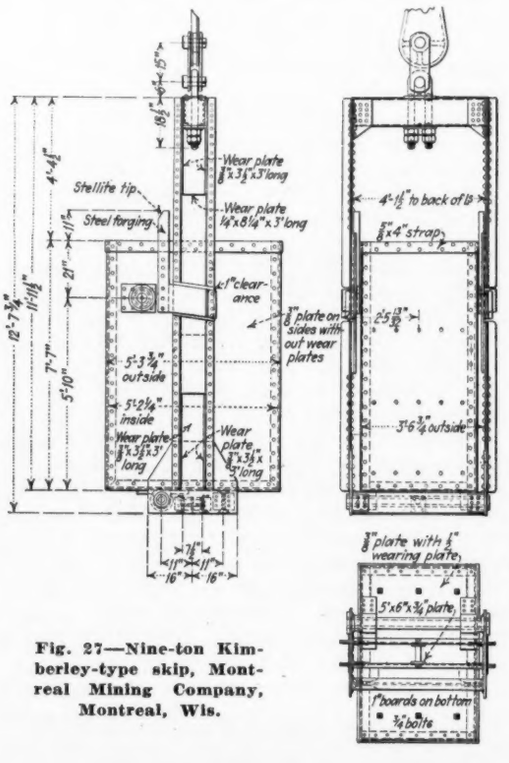


Fig. 27—Nine-ton Kimberley-type skip, Montreal Mining Company, Montreal, Wis.

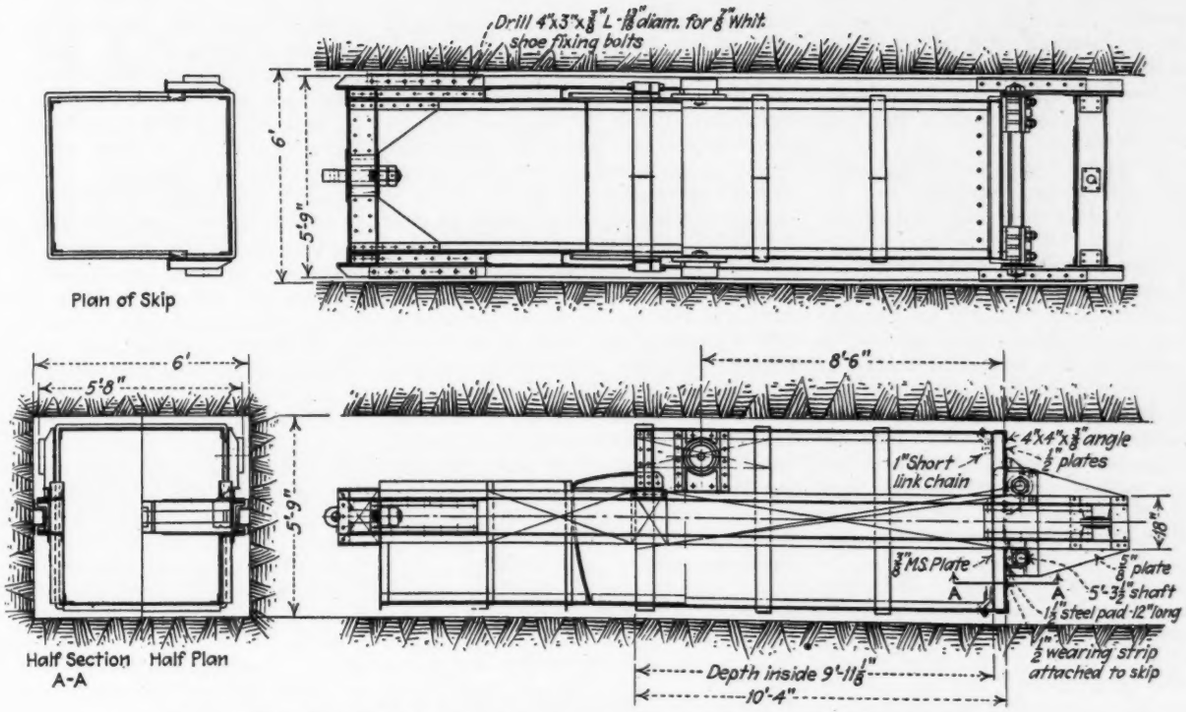


Fig. 28—Ten-ton Kimberley-type skip, Roan Antelope Copper Mines, Northern Rhodesia

Hill, Tenn. On this skip the guide shoes, of cast brass, will run on steel guides. They can be melted down and recast when worn out. On the Kimberley skip the guide shoes are angle irons running the full length of the bail —a practice that reduces wear on the guides. On the Montreal skip the guide shoes have renewable steel liners, which do not extend the full length of the frame.

Clearances between the guide shoes and the guide should be not less than ¼ in. nor more than ½ in. on each side of the guide, and not less than ½ in. nor more than 1 in. between the faces of the guides, if wooden guides are used. These clearances can be reduced somewhat for steel guides.

In designing the box, the volumetric capacity should be 10 per cent greater than the expected load. This will help materially in preventing spill. The volumetric displacement of a ton of broken ore varies from 15 cu.ft. per long ton for hard, specular iron ore, to 20 cu.ft. per short ton for some of the lighter disseminated ores. An average is probably about 18 cu.ft. per short ton.

The box of the skip is ordinarily made of boiler plate, riveted to angle irons in the corners and bound together by straps around the top and middle. These straps should be made of genuine wrought iron, as they must stand much shock. If the ore handled is not abrasive, the plates may be of light material, and lining plates may be dispensed with, except at the points of greatest wear, which are where the ore strikes when the skip is being filled, and the upper half of the front, over which the ore slides in dumping.

A unique type of skip construction is used at the Morenci mine of Phelps Dodge Corporation at Morenci, Ariz. Here the box of the skip is made of three sections each built up of four cast-manganese-steel plates. The joints at the corners of each section are beveled, to facilitate riveting, and flanges are provided on the outside for riveting the sections together. This design, said to save some weight, has an advantage over the usual construction in that extra thickness can be provided in places where wear is greatest and where extra strength is needed to support the rollers and horns.

Wet or sticky ores tend to accumulate in the bottom of the skip, reducing capacity and causing overloading and spill. This tendency is partly overcome by fastening heavy chains, by both ends, in the bottom corners, in such a way that they will flop when the skip overturns; or by lining the bottom part of the skip with Linatex, a soft rubber compound sold by the Wilkinson Process Rubber Company, in British Malaya. The resilience of this compound helps to prevent the ore from packing, and its toughness reduces wear from abrasion.

In all of these skips some trouble is experienced with the skip rollers that engage the track in the dump, and with the dump rollers on which the horns rest at one point in dumping. These rollers should be of steel, and should be bushed. They are difficult to lubricate, especially in wet shafts, and have a tendency to bind and to wear flat. Solid roller bearings, even without lubricant, help to reduce friction, and a generous diameter helps to make the roller turn instead of sliding.

Long narrow skips, which rest on a narrow base, are not stable, especially in shafts that get out of line. Some sort of catch to prevent them from overturning is advisable. These catches used to be tripped as the skip entered the dump, but present practice is to use a flange, fastened to the box of the skip, which rests against one side of the guide. The guide must be cut away to make a path for this flange when the skip enters the dump. The position of

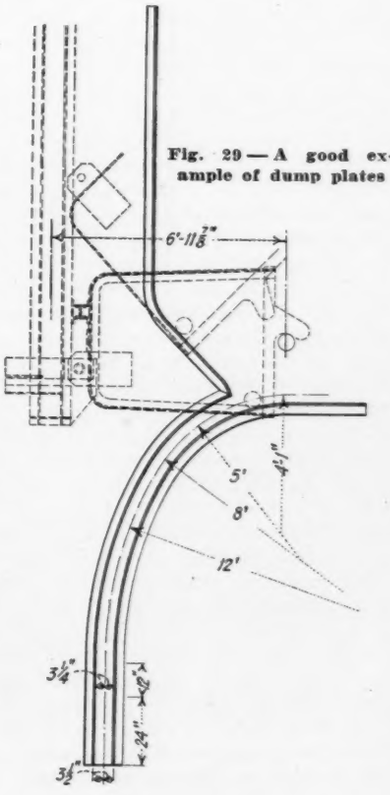


Fig. 29 — A good example of dump plates

the portion that must be cut away is difficult to calculate, and is best determined by "trial and error," using a model drawn to scale. The skip shown in Fig. 27 is equipped with a flange of the kind described.

If men do not ride on the skips, safety catches are neither necessary nor advisable. If, however, men do ride the skips, as in those shafts where no cage is provided, or where cages are substituted for the skips at the end of the shift, a light steel platform for the men to stand on, built on top of the bail, is convenient, and is safe if a bonnet is hung from the hoisting rope over the men's heads. In a skip compartment 5 ft. square in the clear seven men are easily carried on such a platform. This arrangement, in my opinion, is preferable to that of putting the bonnet on the skip bail and having the men ride in the skip.

The skip dump consists of two dump plates, one right and one left, placed exactly opposite each other, on each of which are riveted a track, usually made of angle iron, and a roller, mounted on a pedestal. These dump plates must withstand much shock without distortion, and are therefore usually made of $\frac{1}{2}$- or $\frac{5}{8}$-in. plate. They must be securely fastened in place, and their position in relation to each other and to the guides should remain unchanged. Little trouble is experienced in this regard when the headframe is built of steel; but the opposite is the fact when the plates and guides are fastened to wooden beams.

A good example of dump plates is shown in Fig. 29. The lower part of the dump track is a compound curve, so designed as to equalize the overturning moment and to reduce shock. To minimize this shock, the lowest part of the track may be made movable and held in place by a spring, but this is not common practice.

Although usual practice is to make the dump track out of angle irons, faced with lining straps, my experience has been that to use square iron bars in place of the angles is economical in the long run. The extra weight of metal entailed is fully justified.

In shallow mines, if the hoisting drum is keyed to the shaft or is held by jaw clutches, gates for the skips to rest upon, when they are being filled, are unnecessary; but in mines deeper than 1,000 ft., if gates are not provided or if provision to prevent spill, as in the case of the Roan Antelope skip, has not been made, the hoisting rope will stretch enough, when the skip is being filled, to cause trouble. Chunks will jam between the box and the bail, throwing them out of line and causing trouble in dumping and danger and damage in the shaft. If the hoisting drum is held by a friction clutch, gates are recommended even in shallow shafts.

At the bottom level the gate can be stationary, but on the upper levels it should be hinged, so that it can be thrown back out of the way. It should be so constructed that if left in place by mistake it will be torn out by the descending skip without serious damage to the skip or to the shaft timbers.

The weight of the skip in proportion to the load that it carries varies from 50 to 100 per cent, according to the hardness and density of the ore, and averages about 65 per cent. Usually, the box weighs twice as much as the bail. The design is a compromise between weight and durability on the one hand, and repair cost on the other. Either side is likely to be overemphasized. In equipping a shaft with skips, at least one spare should be purchased at the start. Two spares should be kept on hand, so that one will always be ready for service while the other is out of commission or being repaired.

■ ■ ■

Gold Prospects in Valdez Creek District, Alaska

THE United States Geological Survey announces the completion, by Clyde P. Ross, of a report, with topographic and geologic maps, on the Valdez Creek mining district, Alaska, resulting from a study of mineral resources in the area tributary to the Alaska Railroad during the field season of 1931. Placer and lode deposits are described in detail, and their origin and characteristics are discussed. Data are given on the general geology and probable geomorphic conditions, and the part they played in the formation and distribution of the placer deposits. Inasmuch as considerable time will elapse before this report can be published, a brief summary of some of the results of economic importance in it has been made public by the Survey.

The Valdez Creek district, which lies east of the upper Susitna River, is known principally for its placer mines. Most of the operations have been on a small scale, and large quantities of potential ground remain untested, much of which cannot be conveniently mined by small-scale plants such as are now in use. As the bench deposits mined by hydraulic methods appear to have averaged over 60c. per cubic yard in gold, testing of the less accessible ground seems warranted. If this ground proves workable, it could be handled with the aid of more suitable equipment than is now being used. The future of the district appears to depend mainly on expansion of placer operations.

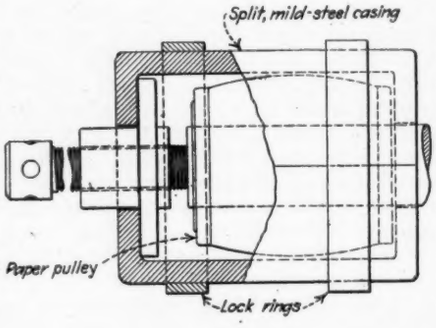
Several gold-bearing lodes are near the placer workings, but these have been only superficially prospected. One of the veins is 1,000 ft. long and several feet wide, but it does not appear to be of high average grade. All the veins appear to have possibilities for future development, but it is doubtful whether they can be extensively developed until, either because of the placers or for some other reason, the transportation facilities are improved.

East of the present confines of the Valdez Creek district, along Clearwater Creek, is evidence of widespread alteration of limestone, schist, and other rocks, with the deposition of pyrite and other metallic minerals. This area has received little attention from prospectors, and might repay examination by those interested in the discovery of metallic lodes.

■

Paper Pulley Puller

REMOVAL of paper pulleys with improper tools often results in waste of time and damage to the pulley, writes Jack Weitzel, master mechanic of Magma Copper Company, Superior, Ariz. A practical puller, developed recently for this operation, is shown in the accompanying sketch. It consists of a split mild-steel casing, two lock rings of the same material, and the steel pressure screw and nut. To operate the device the half casings are slipped over the pulley and locked with the two rings, after which the screw is advanced to the protruding shaft end. Pressure applied by additional turns of the screw then detaches the pulley from the motor or line shaft.



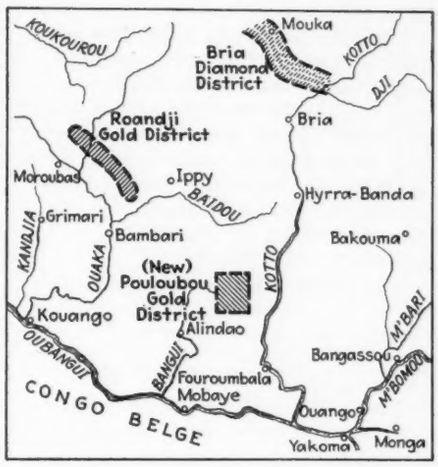
Diamonds in Equatorial Africa

John L. Middleton

IN 1915, a small diamond was found in the vicinity of Ippy, in the Oubangui-Chari, Congo Belge. A company was organized and prospected without success in this region for two years, after which operations were discontinued. About 1926, Compagnie Equatoriale de Mines began operating in the Oubangui-Chari, and sent prospectors to stake claims where indications of the presence of gold or diamonds were promising. Although neither gold nor diamonds in paying quantities were discovered at Ippy, exploitable gold placers were found near Roandji, about 40 km. east of Ippy, and diamond deposits 120 km. northeast of Ippy, in the region of Bria.

The occurrence of diamonds north of Bria was first determined in May, 1928, by a geologist, who found several diamonds in a concentrate that was sent to him by a prospector searching for gold along the affluents of Boulouba Creek. Both men were in the employ of the Compagnie Equatoriale de Mines. A brief description of the Bria diamond fields follows:

Bria is a day's ride by automobile from Roandji, the center of the gold-mining operations of the Compagnie Equatoriale de Mines. From Bria, porters are used to the confluence of the Kotto and Bongou rivers, near which the first diamond exploitation of the Oubangui-Chari is situated. The older rocks of the region are Pre-Cambrian gneisses and crystalline quartzites, intensely folded and planed off by erosion. Lying unconformably upon this erosion surface is a fluvio-lacustrine deposit of cross-bedded sandstones that contain numerous overlapping lenses of conglomerate. Thickness of the sandstone-conglomerate formation is unknown, although indications are that in some places it is at least 150 ft. thick. Well-rounded pebbles of vein quartz, quartzite, chert, and jasper,



Sketch map showing producing districts of the Cie Equatoriale de Mines

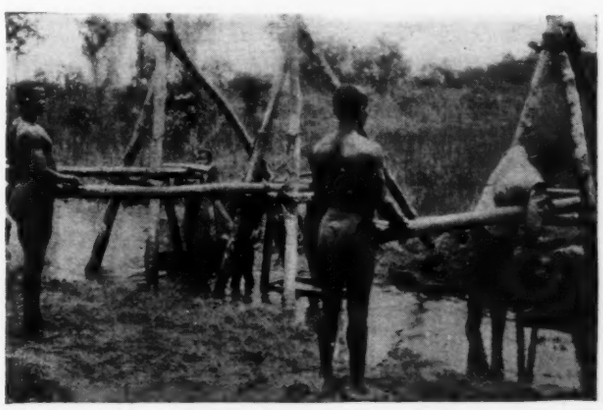
in an arkosic sandy matrix, typify the conglomerate. Sands produced in crushing contain zircon, tourmaline, ilmenite, rutile, and cyanite. Mechanical classification is irregular in the sandstone and conglomerates. In the upper horizons of the sandstone, however, smaller pebbles and fewer lenses of conglomerate are found. The conglomerate dips slightly north-northwest.

The diamonds are found in stream gravel that originated from erosion and disintegration of certain conglomerates. In addition to diamonds, concentrates contain tourmaline, ilmenite, rutile, cyanite, staurotite, zircon, chrysoberyl, and white topaz. Some gold and traces of platinum are also present. Evidence that the diamonds are derived from the conglomerate is conclusive; the surface map shows that relation clearly. The nature of the original mother rock, eroded to liberate the diamonds deposited in the conglomerate, is uncertain. At first, the explanation seemed logical that basic dikes or pipes had eroded with the gneisses and quartzites that furnished the sediments of the conglomerate - sandstone formation. A glance at the list of concentrates, however, shows a preponderance of mineral commonly associated with acid and metamorphic rocks. Ilmenite and platinum are the two exceptions. However, I found quartz veins, carrying abundant ilmenite, within forty miles of the southern edge of the conglomerate. All minerals in the concentrates, therefore, may be of acid origin. Although basic rocks decompose quickly and easily, the presence of a few grains of pyrope or peridot in the concentrates derived from such rocks would be expected. I therefore prefer to leave this question open, and hope that further investigation may make possible a determination of the original mother rock of the diamonds of the Bria district.

The method of prospecting is similar to that employed in the Kasai for many years. Gravel is classified in hand rockers and then concentrated in Joplin hand jigs. Concentrates are picked over by hand as soon as the natives are trained to recognize diamonds. They are more adept than white men at this work. No trouble has been experienced with theft, because the natives do not yet realize the value of the diamonds. As the field develops, however, precautions must be taken to avoid the hazard.

In conclusion, I desire to express my thanks to Compagnie Equatoriale de Mines for permission to publish this article and the accompanying map.

Test-pit prospecting along the Kotto River



Jigging operations in the diamond fields of the Bria district

Science and Principles of Geophysics

Further Reviews by Dr. C. A. Heiland*

HANDBUCH DER GEOPHYSIK. *Band I, Lieferung 1. Contents: B. Gutenberg. Einleitung: Allgemeines ueber Geophysik. F. Noelke. Die Entwicklung des Sonnensystems und der Erde. M. Milankovitch. Stellung und Bewegung der Erde im Weltall. F. Hopfner. Figur der Erde, Dichte und Druck im Erdinnern. Pp. 308; illus. Gebrueder Borntraeger, Berlin. Reichsmarks, 54.*

The first volume of Gutenberg's Manual of Geophysics is essentially of astronomical and geodetic character. It is divided into four sections, under the titles given above. In the introduction, a review is given of the various fields of the geophysical science, and the relation of geophysics to other branches of science.

The second section deals first with the forces active in the universe, and then reviews the various cosmogonic hypotheses advanced to explain the evolution of the solar system. Evolution of satellites is also treated in the light of these hypotheses. The section concludes with an account of the theories advanced to describe the evolution of the Earth itself up to the beginning of the geologic eras.

The next section is altogether astronomical. After a summary of the development of knowledge of the Earth's movement in space through the ages, Kepler's and Newton's laws are outlined, followed by a detailed mathematical treatment of the theory of motion of two and more celestial bodies. The last chapter deals with the history of discovery, and the path elements of the planets.

In the fourth section, the figure of the Earth is first treated as a geometrical problem; namely, in regard to its determination by purely geodetic means. An analysis is then given of the methods which attempt to treat the determination of the Earth's shape as a physical problem—that is, by an application of the theory of the potential of gravity. The theorems of Bruns and of Clairaut are derived, and the author shows how, under the various assumptions, the shape of the Earth may be derived from measurements of gravity at the surface. Methods used in higher geodesy in triangulation and precise leveling are next reviewed. This is followed by a description of methods for determining the geoid and portions thereof, and reference ellipsoids. The last chapter deals with the theories about the distribution of density in the Earth's interior, and methods for determining the average density by torsion balance and other means.

The reader of this last section may do well to supplement it by perusing the chapters on density, gravity, and pressure in the "Interior of the Earth," written by B. Gutenberg, in the second volume, which will be reviewed next.

HANDBUCH DER GEOPHYSIK. *Band II, Lieferung 1. B. Gutenberg. Abkuehlung und Temperatur der Erde. G. Berg. Chemie der Erde. A. Born. Alter der Erde und Geologische Zeitalter. B. Gutenberg. Der physikalische Aufbau der Erde. Pp. 564; illus. Gebrueder Borntraeger, Berlin. Reichsmarks, 102.*

The main topics treated in the first part of this, the second, volume are related to the geologic history of the Earth, and to the physics and chemistry of its interior. In the first section, Gutenberg describes the results of temperature observations at the surface and in wells, and the thermal and radioactive properties of rocks and formations. This leads to a discussion of theories concerning the cooling of the globe and the temperatures existing in the interor.

The second section deals with general geochemistry (chemical composition of the various zones of the Earth, distribution and migration of chemical elements in geologic processes) and in particular with the geochemistry of the lithophile, chalcophile, siderophile, and atmophile elements. Although geochemistry is a subject which, strictly speaking, is not generally considered a part of geophysics, this well-written account of it will be found valuable when dealing with problems on the border line of geophysics and geology (genesis of mineral deposits and related subjects).

The next section presents a vivid and detailed account of the paleogeographic and paleoclimatologic evolution of our planet. The subject matter is treated from the historical-geologic point of view, with a completeness seldom found in textbooks on stratigraphy and historical geology. This is true in particular for the many charts representing the distribution of land and water and of climates, in past geologic ages.

In the fourth and last section the physical constitution of the Earth's interior is considered. Following an introduction on the theory of elasticity, the distribution of seismic wave velocities, of density and gravity, of the rigidity- and bulk-moduli, and of the viscosity coefficient in the Earth's interior are described. The discussion takes in the most recent data, and is concluded by a summary of our present views about the general physical constitution of the Earth's interior.

HANDBUCH DER GEOPHYSIK. *Band VI, Lieferung 1. H. Reich. Eigenschaften der Gesteine. H. Hunkel. Die elektrischen Aufschlussmethoden. E. A. Ansel. Theorie der gravimetrischen Aufschlussmethoden. O. Meisser: Instrumente der gravimetrischen Aufschlussmethoden. Pp. 312 illus. Gebrueder Borntraeger, Berlin. Reichsmarks, 63.*

The sixth volume of the Handbuch will probably be of greatest interest to the readers of this publication, as it deals with geophysical methods of prospecting. The first part of it, now available, covers the physical properties of minerals and rocks, some of the gravitational methods, and electrical methods of prospecting.

After an introductory chapter on principles, classification and range of application of geophysical methods, a thorough discussion is given of such properties of minerals, rocks, and formations which are of importance in interpreting geophysical effects; namely, specific gravity, elastic properties, electrical conductivity, magnetic properties, and dielectric constant, radioactive, and thermal properties. A great number of tabulations are given covering most of the material thus far published; this chapter represents probably the most complete account of physical properties of rocks which is at present available. Methods for determining these properties are not described in this chapter. A discussion of them is left to the chapters on each individual method.

The next section, on electrical methods, is perhaps a little too short, particularly with respect to descriptions and illustrations of methods and instruments, in view of the recent developments in the art of electrical prospecting. The electrical methods are divided into (1) methods using spontaneous polarization; (2) methods using extraneous currents; (3) and methods using high-frequency radiations. In view of the great importance which resistivity methods have attained lately (about seventy articles have appeared on this phase of electrical prospecting during the past four years), the results obtained by the use of this method in civil engineering and in structural and ore prospecting might have been stated in greater detail. I believe that hardly anybody will share the author's adverse criticism of the Gish-Rooney and other resistivity methods which seems to be based on some controversy of his with Schlumberger. The account of the theory of the potential

*Sections of the Handbuch der Geophysik previously received were reviewed by Dr. Heiland in the January, 1932, issue.

distribution in homogeneous and inhomogeneous ground for direct and alternating current is well presented, and is followed by a description of the equipotential and potential profile method. The space devoted to the electromagnetic and, in particular, to the inductive methods seems somewhat limited, in view of the fairly abundant data available in recent literature on the theory and results of the Sundberg inductive method in structural work. The last chapter, on electrical prospecting, is devoted to discussing future possibilities of the methods.

The third section of the book deals with the theory of relative gravity determinations, especially the theory of various factors, like flexure of the support, affecting the results. The theory of the torsion balance is derived, and a description of instrument types is given. Formulas for computing gradients and curvatures are presented, and methods for terrain correction are discussed. Little is said about graphical terrain correction methods. Then follows a statement of the formulas for the effect of subsurface masses of simple shape, and two diagrams illustrating a new graphical interpretation method. This chapter may have been supplemented to advantage by more frequent references to the newer literature on terrain and interpretation methods.

The fourth and last chapter of the book is devoted to a description of instruments and methods for pendulum observations, with a rather complete account of the theory of various corrections, a topic which is covered to some extent also in the third chapter of the book. Valuable information is given on the computation of pendulums, on the determination and computation of corrections, coincidences, time signals, and related data. A number of figures illustrate the most important types of pendulums and pendulum apparatus now in use.

The second part of the sixth volume of the Handbuch will contain the last installment on the gravity instruments, a section on magnetic prospecting, a section on seismic prospecting, and a review of other less important methods.

■

GENERAL ENGINEERING HANDBOOK. *By C. E. O'Rourke, New York: McGraw-Hill Book Company, Inc.; $4. London, England: McGraw-Hill Book Company, Ltd.*

This book is the composite effort of 23 college professors and five practicing engineers. Subjects of general import—such as an outline of mathematics, tables of roots and powers, units of weight and measure, and the theory of mechanics and hydraulics—occupy the first six sections. The remainder of the book is confined to the usual handbook material on civil, mechanical, and electrical engineering.

WITWATERSRAND MINING PRACTICE. *By G. A. Watermeyer and S. N. Hoffenberg. Johannesburg, South Africa: Transvaal Chamber of Mines, Gold Producers' Committee; 45s., post free.*

The interest of the world is so aroused at present on the subject of the gold supply that an exhaustive survey of the South African gold mining industry, which produces half of the annual new gold in the world, is most timely. The authors of "Witwatersrand Mining Practice" are members of the faculty of the University of the Witwatersrand. They have successfully combined the requirements of the practicing engineers' handbook and the students' textbook so far as South African gold mining is concerned. In its 900 pages, with 476 illustrations, dealing with all phases of the industry—history, geology, prospecting, development, extraction, sanitation and health, labor, accident prevention, legislation, economics, and mine accounts—it contains much of interest and value to mining engineers and mine executives. Beyond this, it constitutes a complete compendium of South African conditions and the manner in which they are met. It sets an example which it is hoped may be followed by other laborers in the field. A set of such reference books, covering the non-ferrous metals, would constitute a real mining library.

The list of those whose assistance and cooperation is gratefully acknowledged by the authors affords ample evidence of endorsement by the whole of the industry whose methods and accomplishments they have ably presented.

ARTHUR NOTMAN.

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BERYLLIUM, ITS PRODUCTION AND APPLICATION. *Published by Zentralstelle Für Wissenschaftlich-Technische Forschungsarbeiten Des Siemens-Konzerns. Translated by Richard Rimbach and A. J. Michel. New York: Chemical Catalog Company; $10.*

This comprehensive monograph consists of reports from the Electrochemical Division of Siemens & Halske A.-G. and from the research laboratory of the Siemens concern, representing investigations of the properties and production of beryllium. Preliminary work in the field was started in 1919 by Hans Goldschmidt, the inventor of the thermit process, in collaboration with Alfred Stock. The work of these men, to whom much of the success in developing a process must be ascribed, was taken over by a committee for the study of beryllium, later absorbed by Siemens & Halske, originally a member of this committee.

The German process, operating at a temperature of about 1,400 deg. C. and employing a bath of beryllium oxychloride mixed with barium fluoride, is described in detail. Other chapters deal with the dressing of raw beryl and production of beryllium salts suitable for electrolysis; electroplating with beryllium; electrolytic production of beryllium alloys; studies of structure and physical properties of the pure metal and its most important base-metal alloys; and methods of heat-treatment and age-hardening.

The high expectations held for beryllium have not all come true. The brittleness of the pure metal will probably always be an obstacle to its extensive use in the unalloyed state. Alloys of beryllium with other light metals give little promise. Future developments are most likely to be found in the field of heavy-metal alloys containing a comparatively small percentage of beryllium. Many alloys of this type have already been produced which possess extraordinary strength, hardness, and remarkable fatigue resistance.

A special chapter lists the most important beryllium minerals, their composition and occurrences. One of the problems was to establish a market for beryl. Exorbitant prices are often asked for this mineral, which is recovered as a byproduct in other mining operations. Investigations into known beryl occurrences should lead to more stable conditions, without which successful development will not be possible.

B. H. STROM.

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SILVER STRIKE. *By W. T. Stoll and H. W. Whicker. Boston: Little, Brown & Company; 273 pp., illus.; $2.50.*

The comparatively recent death of W. T. Stoll, whose recollections of the early history of Coeur d'Alene mining are recorded in this volume, is a reminder that few more personal narratives of this kind, descriptive of frontier times, can be expected. Mr. Stoll, a Spokane lawyer, has recounted the details of stirring times, of booms and lawlessness, of stampedes and labor dissentions. As a lawyer in the famous Bunker Hill & Sullivan case he took part in the determination of vast natural resources. "Silver Strike" is therefore historically informative as well as interesting.

■

1932, TRANSACTIONS, A.I.M.E., GEOPHYSICAL PROSPECTING. *New York: American Institute of Mining & Metallurgical Engineers; $5.*

This volume contains papers and discussions presented at the New York meetings of the Institute in 1929, 1930, 1931 and 1932. After two general papers, the following methods are treated: resistivity, electromagnetic, magnetic, seismic, gravitational. The book concludes with a discussion of various theoretical phases of the subject.

SOUTH CENTRAL AFRICA. *By Owen Letcher. Published by African Publications, 43-44 Calcutta House, Loveday St., Johannesburg, South Africa. De luxe edition, 27s. 6d.; ordinary edition, 18s., Union currency.*

To all who plan to visit South Central Africa, and to men and women who have a special interest in the territory embraced in the title, Mr. Letcher's latest work will prove of practical value. In fact, it is a guidebook of the region discussed. Not alone is the historical and the industrial record set forth, but such data as game laws, airplane-service time tables, and similar essential information for the traveler are presented. A large part of the volume is devoted to consideration of the copper industry of the Belgian Congo, its historical development, present status, and its future. Mr. Letcher takes vigorous exception to the alleged menace of the so-called African "slave copper." His theory as to the benefits of white rule in Africa unfolds the concept that it affords the only protection that the natives have ever possessed, against human degradation, slavery, cannibalism, disease, and misery. Most readers will accord him the credit of proving his case. His present work is of especial value to mining and metallurgical engineers, to industrialists, to travelers, and to so-called big-game hunters. What with high licenses, absolute prohibition of slaughter, importation of rifles in bond, and other restrictive regulations, the camera would now seem to be the preferred weapon. Mr. Letcher is a colorful writer on African resources and affairs. His breezy, pungent style and his command of his subjects make of especial interest such publications as a facile pen and a trained journalistic technique inspire him to set before the world.

W. N. P. REED.

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BOOK OF METALS. *By Donald Wilhelm. New York: Harpers & Brothers; $4.*

A popular and well-prepared account of the history and economics of metals from the earliest times to the present day. Data on uses and characteristics of metals and alloys illustrate the important part they have played, are playing and are destined to play in the advance of a machine age.

■

RAND GOLD MINES. *By E. Sturzenegger. London: Published by the author at 4 Copthall Buildings, E.C. 2; 10s. 6d.*

This is the second edition of a comprehensive book dealing with the outstanding mines of the Witwatersrand. As the author states in his foreword, the great Rand gold mines are particularly attractive to the investor, not only because the price of their product is not affected by depression, but also because of the complete information that they furnish shareholders. Probably no other group of industrial undertakings summarizes its financial results more frequently or more completely than the Rand mines. Mr. Sturzenegger sets forth in simple terms the position of each of the mines.

■

MINING YEAR BOOK FOR 1932. *By Walter E. Skinner. London: Walter E. Skinner, 15, Dowgate Hill, E.C. 4; 20s. Post free (inland) 20s. 9d net; Post free (abroad) 21s. 6d. net.*

A total of 1,285 different mining companies are described in this annual compendium. The number is smaller than in previous years, due to the absence of new flotations and a mortality accentuated by depression. As usual, complete data regarding capitalization, profits, and dividends of each of the companies described are included. Statistical tables and a convenient dictionary of mining terms add to the value of the publication for the mining investor or the mining engineer.

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A PRIMER OF MONEY. *By Donald B. Woodward and Marc A. Rose. Pp. 261; illus. New York, N. Y.: Whittlesey House, McGraw-Hill Book Company, Inc.; $2. London, England: McGraw-Hill Book Company, Ltd.*

In this treatise is presented an analysis, written for the layman rather than the economist, of the origin, growth, development, and present operation of money and monetary systems. It should prove helpful to students who are unfamiliar with the terms employed by experts, but who wish to maintain an intelligent interest in the changes occurring in policy and practice throughout the world.

■

SYMPOSIUM ON EFFECT OF TEMPERATURE ON THE PROPERTIES OF METALS. *Joint Meeting of the American Society of Mechanical Engineers and the American Society for Testing Materials. Pp. 829; illust. Philadelphia, Pa.: American Society for Testing Materials, 1315 Spruce Street; $6.*

The 27 papers in the book are largely compilations of data from many sources, domestic and foreign. It is divided into two general sections, the first dealing with engineering trends and requirements for metals at high and low temperatures, and the second with the properties of available metals for such service. Steps have been taken to make the book a ready reference volume, in regard to specific as well as general topics. It has an extensive subject index and a bibliography containing 600 annotated references.

THE PARADOX OF PLENTY. *By Harper Leech, with an introduction by Virgil Jordan. New York, N. Y.: Whittlesey House; $2.50.*

Distributable energy is shaping the world economic structure of tomorrow, says Mr. Leech, who envisions a much simpler world for our descendants. A wider application of electrical power will overcome the handicaps of centralization and congestion, and a less integrated society will evolve a new social cult of a quasi-religious character. This silver lining that the author would show behind the clouds of today's depression is enhanced by analytical discussion of current economic problems, presented in readable style.

■

SCIENCE AND FIRST PRINCIPLES. *By F. S. C. Northrop. Pp. 299; illus. New York, N. Y., The Macmillan Company, 60 Fifth Ave.; $3.*

An exposition, in non-mathematical language, of the theory of relativity, quantum, and wave mechanics, the second law of thermodynamics, the physiological nature of life, and certain genetical and neurological theories of the nature of man. The book is specifically scientific in some details, and broadly philosophical in others, illustrating the bearing of one branch of science on another, and the relation of all of them to philosophy.

■

LIQUID-OXYGEN EXPLOSIVES. *By G. St. J. Perrott and N. A. Tolch. Bulletin 349, U. S. Bureau of Mines. Superintendent of Documents, Washington, D. C. Price 25c.*

This bulletin, the latest to appear on the subject of liquid-oxygen explosives, summarizes the results of tests made to determine the most efficient and safe way of using them and gives a résumé of the experience gained to date. Thus far their adoption for underground blasting has been limited. They find their best application, at least in the United States, in open-pit work and stripping, especially where cartridges of large diameter and of long explosive life are used.

■

STANDARD CONSTRUCTION METHODS. Second Edition. *By G. Underwood. Pp. 501, illus. New York: McGraw-Hill Book Company, Inc.; $5. London: McGraw-Hill Book Company, Ltd.*

Additions and amplifications characterize the second edition of this textbook, which discusses every detail of construction work, from organization procedure to painting practice. Special attention is paid to the laying of concrete and the hoisting of construction material. New data are included on pipe threading and pipe bending, and on many other subsidiary phases of construction work.

Eagle-Picher's Central Milling Project

R. J. Stroup

ACQUISITION by the Eagle-Picher Mining & Smelting Company of the Tri-State district properties of the Canam Metals Corporation, and of those of the Harry Payne Whitney interests, and the bringing of operations of the Consolidated Lead & Zinc Company under Eagle-Picher management, materially enhanced the Eagle-Picher ore reserves and paved the way for the construction of a central milling plant. The beginning of 1932 found Eagle-Picher with eighteen mills in Oklahoma serving about 2,540 acres of land, six mills in Kansas serving 800 acres, and about 1,200 acres of reserve lands in both states.

A few of these properties are rich and can be operated profitably with a low zinc market; others can produce profitably on about a $30 zinc-concentrate market; some have large quantities of marginal-grade ore at a $30 market; others are able to produce a smaller daily tonnage of ore than the mill on their respective tracts can economically treat, and at still others ore reserves have been depleted. Mills and surface equipment present as varied an assortment as the mines. With few exceptions these plants are old and in bad repair. Most of them have been operated on a falling market until forced to close. To rehabilitate them would cost an enormous sum, and they would still remain small, inefficient, and expensive operations.

Eagle-Picher has elected, through a system of operating efficiencies and rigorous economies, to meet the condition of price, as the company sees it, during the next few years and during the life of the aforesaid ore reserves. As a first step in such a program consideration was naturally given to reducing this large number of independent operating units, with one central unit as the ultimate goal. The management well realized, however, that one large concentrator, unless wisely chosen as to capacity, equipment, and flowsheet, might become a "white elephant" in future years, as ore reserves neared depletion. Sectionalization of certain units has been resorted to in the design of the central mill, but nowhere has the idea of flexibility of tonnage treated with efficiency and economy of operation been overlooked. Although the initial capacity of the central concentrator is conservatively rated at 150 tons per hour, it is replacing mills with aggregate capacities of about 700 tons per hour. However, to operate many of these old mills more than 10 hours daily is impracticable, and the relative capacities become about 3,600 tons per 24-hour day at the central mill and 7,000 tons per 10-hour day at the smaller individual plants.

The advantages of central milling to the mines themselves are of vital importance. It permits selective mining to a degree not possible otherwise. The large amount of storage at the mill, totaling 7,600 tons, and the 350 tons' at each field shaft, make daily fluctuation in tonnage from a single mine of small importance. Tonnages from the various individual mines can be controlled at will, depending on their ability to produce, so long as the total from all mines remains approximately the same. The large amount of ore locked in the system —about two days' run—is a safety factor for continuous mill operation. Breakdowns at either mill or mine will not affect the other part of the operation as quickly as in the old operations, owing to the large storage capacities at every point.

A mine can be depleted at any rate desired, that is, from a few tons daily to full-capacity tonnage of the central mill. On some of the tracts of land are orebodies too small to justify the investment necesssary for even a small, cheap mill. If no investment were necessary for a mill, many of these deposits could be milled profitably. The additional recovery made by a central mill because of better equipment, uniform feed, and continuous operation permits the mining of lower-grade deposits than is possible under existing conditions. One acquainted with the vast quantities of "marginal-grade" ores at certain of the company's mines can appreciate what 1 per cent additional recovery means in additional ore these mines can ultimately produce.

To a landowner holding a 10 per cent royalty interest, an additional 1 per cent increase in recovery means an increased royalty of 3c. per ton of ore, or $12 per day, assuming production to be 400 tons daily and a $30 zinc-concentrate market. A central milling scheme permits practically consummate depletion of reserves —far beyond the point possible with an individual mill of fixed tonnage. The life of a mine is lengthened, resulting in royalty over a longer period of time, as well as in more royalty from increased recoveries. The surface of the land is not destroyed for agricultural purposes, as only field shafts are necessary. Whereas, with individual operations, a mill site with ponds and a tailing pile are required. To the operator, a 1 per cent increase in recovery, if attained, means a saving of 36 tons of concentrates daily, based on 3,600 tons of feed. In a year of 350 days this amounts to 12,600 tons, which, on a $30 zinc-concentrate market, is worth $378,000 gross. This is a saving which formerly went directly into the tailing.

Summarized, the principal advantages of a central milling plant are:

1. Better recovery because of:
   (*a*) Better equipment.
   (*b*) Continuous operation.
   (*c*) Uniform feed, as to quantity, character, and grade.
   (*d*) Better supervision possible than at a large number of units.
2. Lower milling costs because of:
   (*a*) Large tonnage handled per man.
   (*b*) Lower power costs, owing to less connected load and continuous operation.
   (*c*) Lower cost of repairs and supplies due to better design, construction, and equipment.
3. Better control of grade of concentrate produced.
4. Elimination of duplication in costs that are incidental to a multiplicity of operations.
   (*a*) Reduction of overhead, watchmen, insurance, taxes.
5. Investment is less than for the individual units it replaces.

Ores from the various mines are hoisted and stored in field hoppers of 350 tons' or more capacity, in the manner usually employed in the district. Transportation is by standard-gage 30-ton air-dumped cars, hauled over the existing lines of the Frisco and the Northeast Oklahoma railroads, upon which trackage rights have been secured. The network of tracks in the district requires the use of a comparatively small amount of spur tracks to serve any property that may be drawn into this project.

Each 350-ton hopper of ore is considered a unit and comprises a trainload. It carries a serial number that is assigned when the train is dispatched for the ore. This number accompanies the ore through the sampling stage, into the assay office, and through the accounting department. The ore is dumped separately into one of four subsurface hoppers at the mill, predetermined by its serial number. It is then run separately through primary crushers, and an adequate sample properly taken. After the sample is taken the ore is dumped into a 5,000-ton storage hopper, where

Abstract of paper presented at annual meeting of the American Zinc Institute, held in St. Louis, Mo., April 18-20, 1932.

it loses its identity and joins other units of varying grade and character. Under this arangement the mill at all times receives a constant and uniform feed.

The movement of each unit of ore is guarded carefully. A stamping device at each shaft imprints a number on the serial card, which serves as a check and shows the origin of the ore. The unit cannot get mixed with any other batch en route because it, and it only, comprises a trainload. On arriving at the mill an automatic Streeter-Amet recorder stamps the net weight of each car on the same serial card that followed the ore from the shaft. A clerk totals the weights, and the train is directed by a semaphore system onto the track whose number corresponds to the hopper number on the serial card.

If the subsurface hopper is not clear of the previous unit of ore, the train cannot enter the dumping tracks. Once in the hopper, the ore takes its turn in being drawn off, as the four hoppers are run in rotation; the serial number scheme is carried through at every point. If, because of repairs or for other reasons, the drawing off of a hopper must be delayed, the serial card must reveal the fact, the necessary control operations must be performed, and the systematization of the scheme kept intact. In like manner, chute gates from the hopper to the primary crushers cannot be unlocked until the corresponding sample hopper is clear.

Details of the control mechanism are too lengthy to be discussed here. They include numerous features that prevent a unit of ore from moving incorrectly. Even if a deliberate error is made the system cannot proceed until the error is corrected. Each unit of ore is assured complete separation from other ores through the transportation, weighing, storage, primary crushing, and sampling stages. The interlocking mechanisms are not highly complicated, but they are positive in operation. Their operation requires no special ability. The movements are all mechanical and may be handled by a clerk.

As stated previously the unit of ore is about 350 tons, which is about the capacity of each field hopper at the mines where the ore originates; it comprises a trainload and fills a designated one of the four subsurface hoppers. Each unit is handled separately through the primary crusher, where it is crushed to about 3 in. It then passes onto a conveyor belt and an automatic sampler cuts all of the stream of this belt for 10 per cent of the time and deposits this cut of about 35 tons into a sample hopper that corresponds in number with that of the primary hopper whence the ore was drawn. The remainder of the unit is discharged into a 5,000-ton storage hopper at the head of the mill.

In due course, the aforesaid 35-ton sample, still under the control of the interlocking system, is crushed to 1¼ in. in a jaw crusher, and 90 per cent of the product rejected into the 5,000-ton hopper. The remaining 10 per cent, 3.5 tons, is ground by high-speed rolls to about ⅜ in., and 90 per cent of the product is rejected, leaving a sample of about 700 lb. This is ground finer on a sample grinder, 50 per cent of the product is automatically rejected, and the remaining 350 lb. reduced by hand on riffles until the sample is of desired size. Part of the serial card, torn off as the train is dispatched for the ore, is sent to the sample mill. This part of the card, containing all the information necessary to identify the sample, is placed in the sample can and accompanies the sample to the assay office.

The serial card contains the full history of each unit of ore. It is a permanent record. It contains the name of the mine and stamped check number of the mine from which the ore originated. It contains the net weights of each car and the total weight. It contains the date, hour of the day, and the signature of each man who supervised the movement of the unit. On reaching the accounting office, various other information is entered on the reverse side of the card, including head assays, moisture content, tailing assays, and amount of concentrates recovered. On these data are based all settlements, whether they be for royalty payment or purchase or custom milling charges.

The settlement procedure is as follows: Moisture is deducted from the recorded weight to obtain the net weight. The weighted composite tailing assay for the day following the arrival of the ore at the mill is deducted from the head sample assay. The amounts of lead and zinc concentrates produced are calculated. Lead content of the zinc concentrate is deducted, and the zinc content of the lead concentrate is likewise deducted. This leaves a theoretical production, any deviation from which is absorbed by the company. Concentrate may be either stored or loaded direct into cars for shipment.

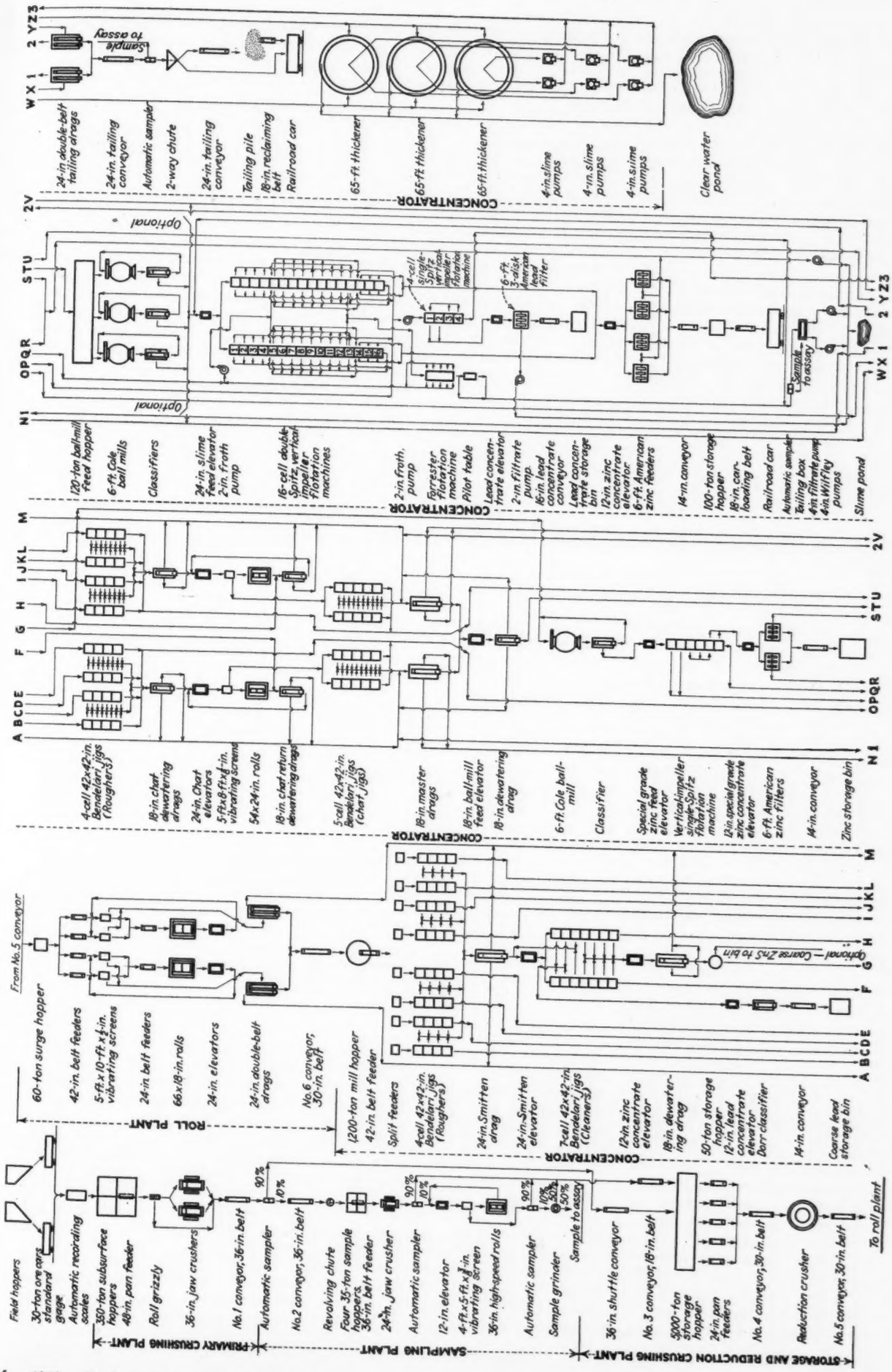
In the design of this central plant an attempt has been made to have every part of the flowsheet as flexible as possible. The metallurgy of Tri-State ores is rapidly improving, and the model mill of only yesterday is, in many phases, obsolete today. In physical arrangement of equipment, future events have been provided for so far as possible, with the view that coming years may bring changes in flowsheet and relative capacities. The future needs of the smelters have not been overlooked and separate circuits have been installed through the ball mill and flotation systems to permit making any special grade or grades of concentrate that may be desirable.

To aid continuous operation, and to take care of alterations in tonnages milled, the plant is sectionalized so far as practicable. For instance, the primary crushing plant has two jaw crushers that may be operated independently or together. This primary crushing plant has a capacity of 400 tons per hour and runs "wild" into 5,000 tons of storage. From this storage, the reduction crusher and roll plants take 225 tons per hour. The roll plant is divided into two separate units. Excess crushing capacities, together with large storages, permit these crushing plants to be operated less than full time, providing opportunity to effect repairs.

A brief discussion of the flowsheet follows: From the four primary subsurface hoppers, each of 350 tons' capacity, the ore is moved by a 48-in. pan feeder onto a roll grizzly, from which it passes to two 36-in. Webb City jaw crushers that reduce it to 3 in. This product is conveyed on a 36-in. belt to a transfer point, where 90 per cent goes onto a shuttle conveyor for distribution in a 5,000-ton storage hopper and 10 per cent goes into one of four sample storage hoppers. From underneath the 5,000-ton storage hopper, the bottom part of which is in the ground, the ore is fed by five pan feeders onto a 30-in. conveyor that discharges into a cone-type reduction crusher. The drawing of ore from this 5,000-ton hopper at five points aids in mixing the ores, which may be of different grade and character, and helps to insure a feed of uniform grade to the mill. From the reduction crusher, which is operated in open circuit, the ore is conveyed on a 30-in. belt to the roll plant. Here, it is screened to ½-in. by four 5 x 10 ft. vibrating screens, the oversize going to two sets of 66-in. rolls and then returning by elevators to the same screens. Undersize from these screens goes into two double-belt drags, of the type developed in the district, where it is deslimed and discharged, as prepared jig feed, onto a conveyor that elevates it into a 1,200-ton storage hopper at the head end of the concentrator building. Slime from the drags in the roll plant goes to the thickeners via the master drags, which hold back any oversize material that might be discharged into them.

From the 1,200-ton hopper, the ore is fed by a 42-in. belt feeder to 64 cells of Bendelari-type diaphragm jigs, which are used as roughers and arranged in eight parallel circuits of two four-cell jigs, in series. Each jig is individually motored, and they may be cut in or out in pairs without impairing the efficiency of the other jigs. These jigs make the usual smittem, chat, and tailing products. The tailing is discharged into two double-belt drags, which, in turn, discharge onto a tailing conveyor that carries the product to waste.

The chats go to two pairs of 54-in. rolls that operate in closed circuit with two 5 x 8 ft. vibrating screens with ⅜-in. openings, the undersize going to four five-cell Bendelari diaphragm chat jigs. Tailing from these jigs joins the rougher jig tailing and both go to waste. The hutch products go to the ball mill feed.



Flowsheet of Eagle-Picher's central milling plant

Smittem from the roughers goes to two seven-cell Bendelari diaphragm cleaner jigs. A coarse lead concentrate is made on the first cells. This goes to a storage bin. On the remaining cells, where coarse zinc concentrate is customarily made, three alternatives are open: (1) concentrate may go to a separate ball mill and flotation circuit provided to produce a low lead-zinc concentrate; (2) the coarse zinc concentrate may go directly into storage bins; (3) these last cells may be operated as roughers, and the hutch product join the regular ball-mill slime circuit. Details are shown on the accompanying flowsheet.

Bendelari diaphragm jigs, of the new crosshead type, are used exclusively in the jig circuit. Each of the 22 jigs, comprising 98 cells, is individually motored. Additional space is left within the building for six additional jigs, with a total of 28 cells, which will materially increase the capacity of the jig end of the mill.

Fine grinding is accomplished with four 6-ft. Cole ball mills, arranged so that three are on the regular slime circuit continuously. One may be used either as the other three are used or for grinding the cleaner jig zinc concentrate for the special grade flotation circuit. Flotation is accomplished on 42 cells of machines of the vertical impeller type. Tailing will be finally cleaned on a Forrester machine. The flow through these machines is shown on the accompanying flow sheet. Seven 3-disk 6-ft. American filters are used: twelve disks on the regular grade zinc flotation concentrate, which discharge onto a belt that goes direct to railroad cars without rehandling; six disks serve the special grade zinc circuit, and three disks the lead circuit.

Much of all this equipment has been salvaged from the mills dismantled because of the erection of the central milling plant. Make-up water going to the mill pond is from a deep well and from mine pumping operations. The deep-well water will be used in the flotation circuit. Slimes will be handled in three 65-ft. thickeners. Actual construction of the central mill has been under way since April. Within the next few months Eagle-Picher's contribution to the improvement of mining and milling of Tri-State ores will become an accomplished fact.

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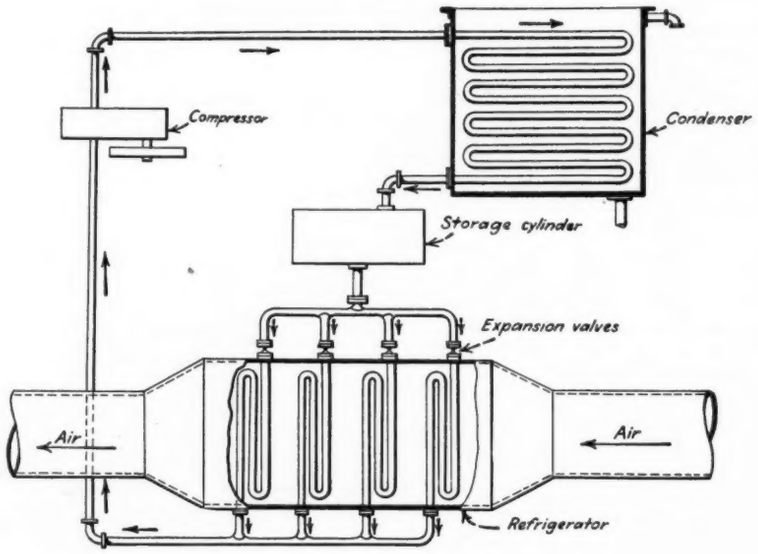
Cooling Mine Air by Ammonia Refrigeration

USE of an ordinary refrigeration plant to cool air in mines has been proved practicable on the Witwatersrand, according to a report received from Johannesburg. Ammonia gas is used as the heat-transfer agent. If leakage occurs its presence is disclosed by smell, and it is therefore preferred to carbon dioxide.

The accompanying diagrammatic sketch depicts the plant layout as installed underground at the property of the Randfontein Estates Gold Mining Company. As shown, ammonia gas, compressed to 200 lb. or more by a compressor, manufactured by J. & E. Hall, of Dartford, England, passes into a condenser, where it is cooled and converted into a liquid. The condenser consists of a series of ¾-in. diameter coils immersed horizontally in a water tank, with water entering at the bottom and flowing out at the top. Liquefied gas flows to a spherical receiver conveniently arranged below the condenser. The pipes between the compressor and condenser carry gas at high temperature and those between the condenser and storage cylinder liquid at atmospheric temperature. Expansion valves of the needle type, to give close regulation of the amount of liquid passing the valve, are placed in the tubes between the storage cylinder and a series of coils, arranged in one or more banks, over which the ventilating air passes. The liquid, dropping in gage pressure at the expansion valves from about 200 to 10 lb., flashes into gas and absorbs heat during the process. To obtain a maximum efficiency, all of the air used for ventilation should pass over the refrigerator coils, as it is invariably saturated with moisture at high temperature and will deposit a considerable proportion of this moisture when cooled. Should only a part of the air be passed over the refrigerator coils, the moisture will freeze, and the ice will choke the passages.



Ammonia consumption is within economical limits. For instance, with an air circulation of 100,000 cu.ft. per minute at a normal water-gage pressure of 2 in., the amount of ammonia required to reduce the temperature from 86 to 60 deg. F. is 260 lb. This figure is arrived at as follows: Reducing temperature causes contraction in volume, and the volume of the aforementioned quantity of air at 60 deg. F. is 95,000 cu.ft. The weight of 100,000 cu.ft. of saturated air at 86 deg. F. is 200 lb., whereas the weight of 95,000 cu.ft. at 60 deg. F. is 78 lb., making a total of 122 lb. of water condensed during the temperature drop. Latent heat of this amount of water vapor at 60 deg. F. amounts to 130,000 B.t.u. Neglecting sensible heat, each pound of ammonia evaporated absorbs 500 B.t.u. For the absorption of 130,000 B.t.u. 260 lb. of ammonia is therefore required.

Accidental poisoning is prevented by the use of gas masks as soon as leakage is detected. If the refrigerator must be emptied, the ammonia gas is discharged into a pump sump, from which it is delivered to the surface in the usual way.

Personal Notes . . . Comment . . . Criticism

C. K. McArthur, of The Dorr Company, is in Chile.

J. M. Callow is returning to London from New York.

R. M. Roosevelt has been reelected president of American Zinc Institute.

W. L. Brown has resigned as director and officer of Gold Recovery Corporation.

J. V. N. Dorr, now in Europe, expects to return to New York toward the latter part of May.

George D. Barron, of Rye, N. Y., has been elected to the Executive Committee of Engineering Foundation.

C. W. Burgess, of The Dorr Company, has left New York for the Orient, expecting to be away about six months.

J. M. Lee has joined the staff of the Dings Magnetic Separator Company, with headquarters at Los Angeles, Calif.

S. D. Strauss, until recently assistant editor of *Engineering and Mining Journal,* has been appointed editor of *The Madison* (N. J.) *Eagle.*

E. B. Freeman, for many years vice-president and general manager of the B. F. Sturtevant Company, has been elected president.

Eugene A. White, formerly smelter superintendent, has been appointed general manager of the Tacoma Smelting Company, Tacoma, Wash.

J. S. Godard, formerly of the Canadian Department of Mines, is now in charge of metallurgical research for Canadian Industries at Toronto, Ont.

H. D. Ruhm is now established as an independent consultant, specializing in phosphate rock, with headquarters at 305 West 7th St., Columbia, Tenn.

G. N. Helling recently returned from Honduras to Guatemala City, Guatemala, and left again for Honduras and Nicaragua on mine examination work.

Robert C. Stanley and **Dr. Paul F. Merica** are in England inspecting International Nickel plants there, expecting to return to New York late in May.

E. W. Berry, formerly with Benguet Consolidated, P. I., has joined the staff of National Exploration, Arizona, and will take charge of mill construction and shaft sinking.

E. W. Beddow has been appointed chief clerk of the smelter division of the Copper Queen Branch of Phelps Dodge Corporation, with headquarters at Douglas, Ariz.

J. H. Gillis recently completed a two-year contract with the Soviet Government and is now in the United States. He will return to Russia on a renewed contract on May 12.

A. H. Richards, for the past five years manager of the Tacoma smelter, has been made Pacific Coast manager for American Smelting & Refining, with headquarters at San Francisco.

O. A. L. Whitelaw has resigned his position as Director of the Gold Coast Geological Survey, West Africa, after eleven years' service. Mr. Whitelaw was formerly on the Victorian Geological Survey staff.

H. W. Gepp, consultant on development to the Commonwealth Government, has accepted a seat on the board of Gold Mines Development, which company is unwatering a promising gold mine at Trentham, Victoria.

R. W. Prouty returned to New York, en route to California, recently, after completion of a two years' contract with the Tzvetmetzoloto, the U.S.S.R. state trust for non-ferrous metals and gold. Mr. Prouty acted as consultant in the Transcaucasus.

C. V. Smith, formerly chief engineer for Asbestos Corporation, Thetford Mines, has returned to Asbest, U.S.S.R., after a brief vacation in Quebec, to resume duties as consulting engineer to Uralasbest Trust, in the development of the Russian asbestos industry.

Dr. R. S. Hutton, director of the British Non-Ferrous Research Association, has been appointed to the new chair of metallurgy established at Cambridge University as a result of financial cooperation of the Goldsmiths Company, one of the oldest London guilds.

F. S. Turncaure, former instructor in geology at the Michigan College of Mining and Technology, is now an instructor in petrology at Harvard University. He left Houghton, Mich., in 1928, for the Patiño property at Llallagua, Bolivia, where he remained for three years.

Dr. T. A. Rickard has been awarded the gold medal of the Institution of Mining & Metallurgy, to be presented at the annual meeting on May 19. The citation pays tribute to "his services in the general advancement of mining engineering, with special reference to his contributions to technical and historical literature."

E. R. Cullity, S. E. Hollister, T. H. Oxnam, and **B. R. Kinney,** of Southwestern Engineering Corporation, have returned to Los Angeles from Russia. Since 1930 this group has been giving technical aid in ore-dressing plant design and installation to Giprotzvetmet, the State Institute for Planning Non-Ferrous Metal Plants of U.S.S.R.

Dr. Arthur R. Andrew has been appointed professor of mining at the University of Otago, New Zealand, in succession to Professor James Park, who recently resigned. Dr. Andrew was recently in charge of the Shell Royal Dutch operations in the United States, and lately has been engaged in consulting geological work in New Zealand.

Dr. C. A. Heiland announces that a short course on the principles and applications of geophysical methods has been arranged by the Colorado School of Mines, from July 11 to Aug. 20. Laboratory and field apparatus is available to permit the student to become familiar with operating technique at a locality suitable for a combination of geophysical studies and vacational recreation.

Dr. Arne Bugge, government geologist, Norwegian Geological Survey, and President of the Norwegian Institute of Mining and Metallurgy, arrived in New York recently for a three months' visit to the United States and Canada, during which time he will make geological studies of the Pre-Cambrian. He also plans to visit some of the larger quarries and manufacturing plants in the stone industry.

E. H. Garthwaite, of Berkeley, Calif., was presented with the medal and diploma awarded to A.I.M.E. members of 50 years' standing at a recent meeting of the San Francisco section. Mr. Garthwaite was graduated from the University of California in 1880 and studied later at Freiberg. Followed professional work in California, Mexico, Transvaal and Rhodesia, latterly in association with Charles Butters.

J. L. Middleton, who contributes a second article on mining in French Equatorial Africa, is a graduate of the University of Minnsota. Subsequent to experience in the Ray and Miami regions of Arizona, Mr. Middleton was associated with the Forminière company in the Belgian Congo. He is now Ingénieur Gèologue and Chef de la Service de Prospection for the Cie. Equatoriale de Mines.

Newton Wakefield, author of the article on the airplane in mining, is a graduate of Dartmouth College and M.I.T., where he studied aeronautics as well as engineering. Association followed with Hecla Mining, Idaho, and Cia. Minera de San José, near Mazatlan, Mexico. He has since had a wide experience in the initiation and executive direction of air transport services, and plans to fly a party of engineers into the Great Bear region in Northern Canada this summer.

Henry N. Thomson, who describes in this issue a modification of one of the common methods used in plant control and ore analysis work for the determination of copper, is professor of metallurgy at the University of British Columbia. From 1904 to 1907 he was chief chemist for Anaconda Copper, compiling the first edition of "Methods of Analysis." Subsequently he became blast-furnace superintendent and assistant works superintendent. For four years he was metallurgist to United Verde Copper.

Donald B. Gillies has been elected president of the Corrigan, McKinney Steel Company, vice **William G. Mather,** who is now chairman of the board. Mr. Gillies, who was born at Bruce Mines, Ont., is a graduate of the Michigan College of Mining and Technology. For ten years he was general manager of Senator Clark's mining properties in Montana. Followed association in the same capacity with the Parrott Silver & Copper Company. Since 1906 he has been connected with the Corrigan, McKinney company, at first in charge of its Mexican properties and latterly as vice-president in Cleveland.

Profitable Silver Mining

To the Editor:

The following quotation from a personal letter to me from Mr. A. L. Gordon, general manager of New York Honduras & Rosario Mining Company, may be of interest to mine managers generally, as it shows how difficulties may be met and cost adjustments made in order to carry on.

When one considers that this mine is in the clouds in one of the most inaccessible places in Central America, and the mill and the mine buildings are hung on the steep slopes on the most impossible sites, and that this enterprise has been carried on for nearly half a century, weathering endless revolutions, one must doff one's hat to the calm and judicious management that has achieved such success. Mr. Gordon's comments follow:

"I note your remarks about making silver pay under present conditions, and wish to say that so far as I am concerned we have worried so much about it that we don't do it any more. We try to meet the situation by corresponding adjustments and let her go at that. I guess I need not tell you what is necessary when you are suddenly confronted with a 50 per cent drop not only in the gross value of your ore, but more or less as a consequence thereof in the workable tonnage. Most of the suppliers in the States, though hollering about the depression, still continue to charge about what they did before the depression, and I have even noticed here and there a drop in the quality of their product. Recently Honduras decided to go on the gold basis, which results in about a 5 or 6 per cent increase in all our Honduras cash expenditures, such as payrolls, supplies, freight, and incidentals.

"The final figures of our 1931 work have as yet not been compiled, but so far as actual bullion is concerned, this, in the number of troy ounces produced, represents a banner year in the 32 years' history of the company. The 1931 production was about 3,696,000 oz. silver and 15,850 oz. gold, the result of 131,900 dry tons crushed; 20,635 ft. of exploration and development were done, which, compared with the years previous, indicates that we have not succumbed to the temptation of decreasing this very vital operation for the sake of a greater profit, but continued with our exploration and development program on more or less the same basis as when silver was above 50c. Anticipating about a year and a half ago, and with about 27c. silver, that continuation of operations at a profit would soon have to come not from a corresponding increase in the milling grade but largely from a greater tonnage, the matter of additional power capacity became necessary. Accordingly, we installed a hydro-electric plant of 350-kw. capacity, which when completed, the latter part of last year, permitted us to increase our tonnage quite substantially. This is our latest operating basis, which we figure on continuing unless circumstances compel us to change it again. Though we have not the actual statistics, I understand that with our type of mine and its size we are about the lowest-cost producer per ounce operating in the world today."

CHAS. BUTTERS.

Berkeley, Calif.

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Wage Scales

To the Editor:

Referring to the editorial in the March issue, I do not think that most of the technical men who are advocating a copper tariff lay great stress upon the different wage scales prevailing in the United States and in foreign countries as a controlling factor in the cost of production. I once operated where we had a wide choice of mining labor, from Chinese coolies on five-year contract at a total cost of 50c. per day to European miners at $2 per day, and in many cases we found it advantageous to utilize the latter.

The advantageous position of foreign copper producers is doubtless largely due to higher-grade ore, but in many cases their costs are not paid on a gold basis, their supplies are not purchased in a high-tariff market, and they bear a much lower tax burden than is general in the United States. I believe that too little emphasis has been laid on these points.

All these considerations, however, are somewhat beside the real question, for, if it is a fact that enough foreign copper can soon be produced at a cost of 7 or 8c. per pound to supply the world's demand, then it obviously results that, failing a tariff, the American market will be supplied at prices with which no American producer can compete, and our domestic copper industry will be put to sleep for many years to come.

If the United States were committed to a policy of free trade in all commodities, or intended to embark on such a policy in the immediate future, the copper people would probably have to bear their troubles with fortitude; but, since other base metals and nearly every class of raw material is and for many years has been protected by our tariff, the lack of such protection is protested by copper producers, particularly when free copper is advocated by manufacturers or other interests whose prosperity is directly dependent upon the tariff which prevents competition with their products.

The pity of the present crisis is that the copper people did not wake up sooner and that some of them do not yet seem to fully grasp the situation or possibly do not wish to face the facts, because their investment in foreign companies offsets to a large extent their interest in the future of the American industry, from the past profits of which they were able to make their investments abroad.

All that the copper industry asks today is a fair deal in line with the established tariff policy of the United States —no favoritism, but no discrimination.

G. M. COLVOCORESSES.

Phoenix, Ariz.

Obituaries

James P. Rice, shift boss at the United Verde mine; at Jerome, Ariz., Feb. 15; aged 66.

Ralph P. Newcomb, mining engineer; University of California, '06; at Berkeley, Calif., on April 15.

C. J. Levien, a pioneer in the development of New Guinea Goldfields; at Melbourne, Australia; aged 58.

Francis Jenkins; at Moscow, Idaho; aged 82. Formerly superintendent, at Kellogg, Idaho, for Bunker Hill & Sullivan.

Jean Jadot; at Brussels, March 1; aged 70; chairman of Union Minière du Haut-Katanga, Forminière and other companies.

Richard Ernest Griggs; at New York City, March 23; aged 62; representative in the United States of Central Mining & Investment Corporation.

William N. Page; at Washington, D. C., March 7; aged 78. Formerly vice-president of American Institute of Mining and Metallurgical Engineers.

Paul Trumna Boyce; at Salt Lake City, Feb. 23; aged 42. Engaged in mining equipment supply business with Charles Stimpson at Salt Lake City.

Bradford D. Pierce, Jr., at Bridgeport, Conn., April 11; aged 67. For eleven years president of the Connecticut Trap Rock Quarries and for a similar period president of the Connecticut Quarries, its successor.

Gustav Gröndal, at Stockholm, Sweden, on March 16; aged 73. Doctor Gröndal was a prominent and distinguished Swedish metallurgist, known best for his inventions of milling equipment, cylindrical mills, briquet ovens, and magnetic separators.

Jesse A. Zook; at Joplin, Mo., April 19; aged 68; of heart disease. Mr. Zook, a pioneer newspaper reporter, editor, and journalist, contributed the monograph on zinc for "The Mineral Industry" from 1917 to 1929, also acting as news correspondent for *Engineering and Mining Journal* and *Metal and Mineral Markets.*

Edward Koepel, at Freda, Mich., April 4; aged 67. Mr. Koepel has been identified with engineering progress in the Lake Superior copper region since 1880, when he joined the staff of Calumet & Hecla. In 1909 he was appointed mill superintendent for Copper Range, with technical control of the Baltic, trimountain, and Champion plants. Mr. Koepel will be recalled as the author of the article on "Flotation of Native Copper at Freda, Michigan," in one of the 1931 issues of this publication.

Chauncey L. Berrien, assistant manager of mines, Anaconda company; at Mayo Clinic, Rochester, Minn., April 22; aged 53. During his college years Mr. Berrien spent vacations in the mines of the Homestake and Anaconda companies. After graduation (Columbia School of Mines, 1903), he joined the Anaconda company, serving successively as miner, geological assistant, assistant foreman, foreman, assistant general superintendent and general superintendent of mines, finally attaining the position held at the time of his death.

Correlation of Units In Blast-Furnace Design

General view of blast-furnace plant and harbor

The need for drastic operating economies led to the design of a Krupp plant described, characterized by an unusually close arrangement of units and the latest practice and the most efficient equipment for the storage and handling of raw materials.

THE new blast-furnace plant of Fried. Krupp A.G., at Essen-Borbeck, in the centre of the Rhenish-Westphalian industrial region, marks a considerable advance in practice, from both the technical and the economic point of view. Decision to build the new plant was influenced by the severe struggle in the German iron and steel industry owing to the heavy burden it bears for taxation and social-service costs, calling for reduction in the cost of production. In addition, it was necessary to meet Belgian and French competition intensified by the possession of the former German iron works in Alsace-Lorraine.

The fundamental idea underlying the general layout is closer concentration of blast furnaces, steel works, and rolling mills. The molten iron was formerly run from the blast furnace into molds, and allowed to solidify into pigs, next broken up and removed, for remelting and conversion into steel, to a steel plant at a considerable distance from the blast furnace. The iron is now run into ladles and conveyed to the steel plant in the molten state. This saves the cost involved in breaking up, transporting, and remelting.

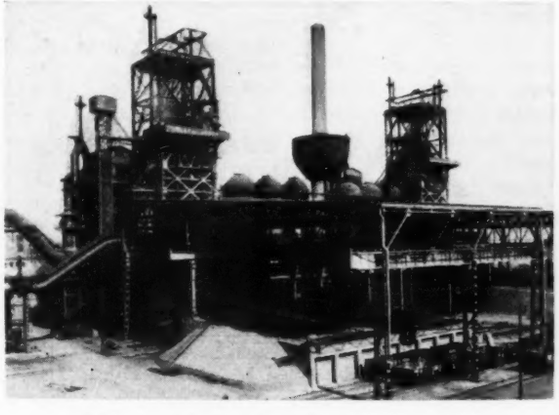
The stockyard at the new Krupp plant can accommodate 150,000 tons of ore. It is spanned by an electrically operated transporter bridge of 25 tons' lifting capacity and 70 meters' span, equipped with a grab weighing 12 tons and capable of holding 13 tons of material. The bridge can easily deal with 250 tons per hour.

Along that side of the ore stockyard which faces the blast furnaces runs a row of elevated stock bunkers; on the side facing the water are continuous sunken troughs for the reception of the ore arriving by water. Above the elevated stock bunkers and the sunken troughs travel the bunker transfer cars.

The method of handling of ore and coke is as follows: Two electrically operated bridges each of a capacity of 150 tons per hour take the ore out of the barges. Each bridge is controlled by a single operator from a cage at the top of the structure. The grabs load the ore into the transfer cars, which in turn deliver it into the sunken receiving troughs. Ore arriving at the works by rail is discharged into the receiving troughs by means of an electrically operated car dumper. The ore stored in the troughs is taken up by the large bridge and dumped on the stockpile or delivered into the bunker transfer cars feeding the elevated bunkers. This system involves little shifting of heavy barges and bridges, while fully utilizing the possibilities of rapid motion afforded by the crane crabs and the bunker transfer cars, a method that saves valuable time. The ore in the elevated bunkers is run into a scale car, conveyed by it to the feed shoot of the skip hoist, raised by the latter to the furnace throat, and there discharged into a revolving distributor hopper of the double-bell type.

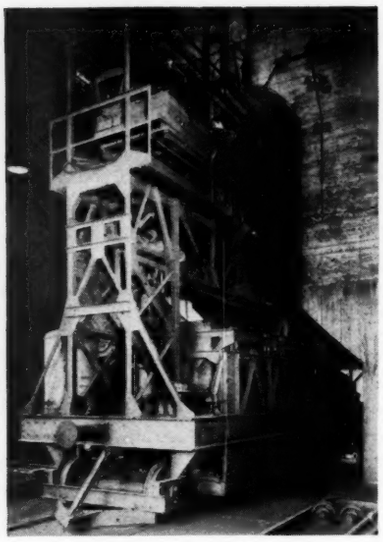
Limestone is also stored in overhead bunkers and charged into the furnace together with the ore. Coke arrives in self-discharging railway cars and is tipped into underground bunkers. From these it falls on to an inclined conveyor, which discharges into elevated coke bunkers, from which it is ultimately delivered over a weighing device into skips. If trouble develops with the large bridge, the coke-handling plant can be utilized for passing the ore to its elevated bunkers. Stoppages in the movement of materials to the furnace are thus avoided.

A further feature is the simple form of electric control adopted for the hoisting and charging gear. These are worked, for each furnace, by a single man from a cabin below the elevated coke bunkers. By merely shifting a lever, the various operations are performed automatically in correct sequence. Each furnace is further pro-



This view shows the compactness of this plant

View of plant from opposite side showing stock bunkers



Ore is run into a scale car from the elevated bunkers

Raw material stockyard at furnaces

vided with an electrically driven vertical hoist for raising men and repair materials to the platforms at top.

Part of the slag from the blast furnaces is treated in a granulating plant for use in the manufacture of cement. The most valuable byproduct, however, is gas, which, when purified, gives better heating effect and can be burned under steam boilers, in the hot-blast stoves, and in internal-combustion engines. In the Krupp plant, the gas, after having been freed from the coarser particles of dust in dust-catchers placed close to the blast furnaces, passes through the crude gas main to an electrical precipitation plant, with a rated capacity of 200,000 cu.m. of gas per hour, which reduces the dust content of the gas to 10 mg. per cubic meter.

About one-half of the total quantity of gas produced by the blast furnaces is consumed by the blast-furnace plant itself in maintaining and heating the blast and generating electric power. The amount of electricity generated in excess of the requirements of the blast-furnace plant is supplied to the main Krupp Works at Essen; the remainder is used in the open-hearth furnaces of the steel-making department.

To sum up, the concentration on one spot of blast furnaces, steel making plant and rolling mills, besides considerably reducing the distance through which the materials have to be transported between the various stages of manufacture, renders possible a more rational utilization of the thermal energy produced; and the extensive application of labor-saving mechanical handling appliances results in a substantial saving in wages.

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Perforated Rubber—A New Aërating Medium

FOR MANY YEARS the General Engineering Company, of Salt Lake City and New York, has been experimenting with numerous aërating mediums with the object of finding one which would aërate a mixture of finely divided solids and water efficiently and give long uninterrupted service. Up to 1928, canvas rotor covers for the company's MacIntosh-type pneumatic flotation machines were used almost entirely. The canvas medium, although meeting the requirements of that time, was not entirely satisfactory, particularly because of difficulties met in high lime circuits and because its short life caused frequent shutdowns for replacement. About this time perforated rubber was introduced, and sheets up to 30 in. wide by 360 in. long were perforated by a number of different methods, with various sizes of holes and perforations per square inch. Different kinds of rubber were also tried out to study the effect of circuit conditions on rubber of various grades. The results of this work disclosed that the use of pure gum rubber stock properly perforated gave considerably increased efficiency with a remarkably long life. This was due mainly to the uniform distribution of a multiplicity of small air bubbles and to the lower resistance offered to the passage of air. Normally, the power required has been reduced approximately 40 per cent, and perforated rubber covers have been in continuous service for a period of one year and longer.

During the past three years, nearly every user of MacIntosh machines has replaced the canvas rotor covers with perforated rubber, and many hundreds are now in daily use.

Perforated rubber, further, has eliminated entirely the difficulties formerly experienced by the use of canvas in high lime circuits.

The thickness of sheet commonly used for aërating flotation pulps is $\frac{6}{64}$ in. or 6/64 in. and perforated with a 0.038 in. punch making 225 holes per square inch. The hole left by the punch, it is found, is considerably smaller than the punch itself and is of dumbbell shape. This peculiar shape of hole has the advantage of closing up due to contraction of the rubber when the air supply is shut off, thus preventing the passage of finely divided solids and water.

To meet the demand for this product, a special method of perforating rubber sheets has been developed which gives a medium of uniform porosity. Patents have been granted for Canada and Mexico and will soon be issued for the United States.

Perforated rubber, it is believed, may be profitably employed in numerous chemical plant operations, and already investigation is under way on applying it as a filter medium for certain crystalline materials, for activating sewage, for liquid purification process, for making up deficiency in oxygen in certain waters, and other similar applications. Each of these uses, the company has found, may require a perforated rubber of different specifications with respect to size of holes, number per square inch, thickness and kind of stock, so that the highest efficiency should not be expected in attempting to use only one type of perforations for all applications.

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Rubber Resists Corrosion

Dr. H. E. Fritz, of the B. F. Goodrich Company, in a discussion before the American Society for Testing Materials, recently declared that more than $200,000,000 annually wasted by corrosion and erosion of pipes and metals in general could be saved by the application of rubber. The cost of this waste is passed on to the consuming public, he said. More than 100 corrosives exist whose destructive action could be stopped by such application.

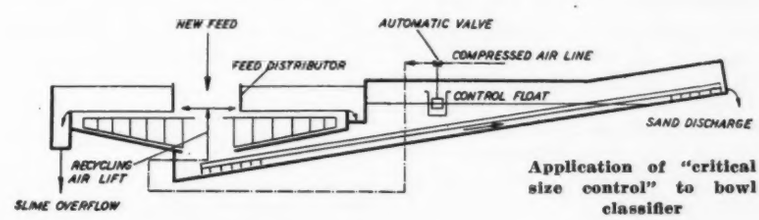
So-called Critical Size Control Improves Bowl Classifier Work

A DEVICE for improving the general operation of bowl classifiers and grinding mills operated in closed circuit with them has been introduced by The Dorr Company under the designation of "critical size control." In the Lake Superior Iron Country and in the Ontario gold areas, where the final stages of its development took place, the device has shown its ability consistently to improve classification by increasing classifier efficiency, circulating sand load and grinding capacity; by reducing oversize in finished product; and by reducing finished product in sand discharge. It may easily be attached to existing bowl classifiers now lacking it.

The fundamental idea leading to this development was the desirability of recycling or recirculating that material of critical size which frequently tended to collect as a dense fluid mass in the lower end of the classifier, directly below the bowl. The size of the particles constituting the mass was so close to the mesh at which the separation was being made that these particular particles remained virtually stationary, being drawn toward the slime overflow and toward the sand discharge by approximately equal but opposite forces. The consequent congestion below the bowl often caused a surging and violent fluctuation of the pulp level in the rake compartment, leading frequently to momentary reductions in capacity and efficiency and impairment of the quality of overflow product, rake product, or both. By recycling this critically sized material under automatically controlled conditions, each particle of it is given several additional classifications, and hence opportunities to leave the circuit as a finished, overflow product. This recycling has its parallel in concentration practice where a middling is returned to the feed for treatment.

The control is simple mechanically. The critically sized material in process of recycling is elevated from the reciprocating-rake compartment to the bowl by means of an air lift, the amount of air admitted to the lift determining the rate of recycling. This is turn may be controlled manually by an air valve or, preferably, by an automatic valve operated by a float in the raking compartment. Experience has shown that the difference in elevation between the pulps in the bowl and in the rake compartment is a reliable criterion of correct classification and elimination of critical-sized material, so the automatic air valve, operated by the float, is adjusted in such a manner as to hold the difference in elevation constantly at the optimum value.

Early in 1932 critical size controls were installed on three large bowl classifiers in the Kirkland Lake, Ont., gold fields. The ore treated was a hard, tough, closely grained quartz-porphyry with admixtures of feldspar, syenite, and diabase. These three bowl classifiers operated in closed circuit with three tube mills, grinding minus 10-mesh ore from the primary ball mills to 92 per cent minus 200 mesh, ahead of the agitation and decantation systems. By the installation, operating results were improved to the extent of a 5.93 per cent increase in over-all capacity, a 17.32 per cent increase in the production of a 200-mesh finished material and an increase of 53 per cent in the circulating load ratio. Furthermore, a much closer separation was made with less oversize in the finished product and less finished product in the circulating sand load, all of which had the effect of raising the over-all classification efficiency 10 per cent.



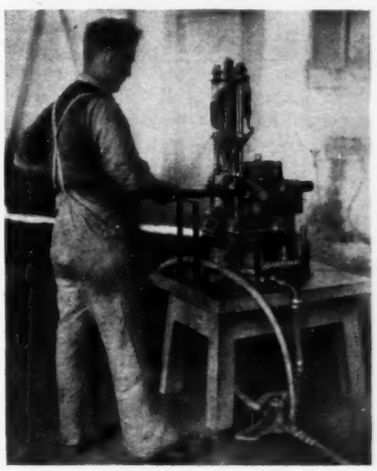
Application of "critical size control" to bowl classifier

A Sump Pump

A centrifugal sump pump of portable type that is expected to find ready application in mines for sinking shafts or winzes and for eliminating seepage and drainage where its capacity meets requirements beyond the range of conventional large sump pumps, has been developed by the Cleveland Pneumatic Tool Company, Cleveland, Ohio, in collaboration with the Deming Pump Company, Salem, Ohio. It is known as the Cleco-Deming pump. It has been designed specifically for general work requiring fast and effective expulsion of water, oil, and other liquids. It is adaptable as auxiliary equipment to steam, electric, and centrifugal pumps where its use will eliminate the need of changing the position of the latter and in dry mines where a few hours a day only are given to the unwatering of seepage. It is also expected to prove useful around pillars in incline mines for removing the seepage from pockets and passing this water along to the larger pumps. Economical operation through saving in air consumption is said to be a feature of the pump. A low center of gravity, moreover, is said to prevent the pump from being upset. An oil reservoir of large capacity is provided.

Drill Sharpener of Unique Design

A new drill sharpener, weighing 500 lb. and capable of making bits up to 2¼ in., has been introduced by Holman Bros. Ltd., Camborne, England, under the name "Newgrip." It uses one hammer for both dollying and swaging.



New drill sharpener with hammer in vertical position

The former is done with the hammer horizontal and the latter with it vertical. In the illustration the hammer is shown in position for swaging. The grips are operated with a force of over 1,500 lb. by a foot control. For the hammer a hand control is used. Swaging as well as upsetting is done by a succession of fast blows. Steel is cramped for upsetting by direct air pressure, without the aid of any mechanical devices.

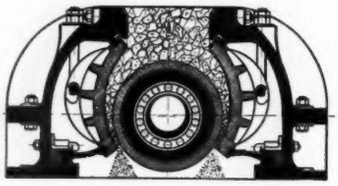
Tank Car for Dry Materials Unloads Automatically

A self-unloading tank car for transporting dry commodities in bulk has been developed by the General American Tank Car Corporation in conjunction with the Link-Belt Company. It is known as the "Dry-Flo," and is reported to be handling such commodities as cement, dolomite, pebble lime, and hydrated lime successfully. It has six openings in the top for loading instead of one opening, and unloads automatically through one opening in the bottom. It has three compartments, a small one housing the unloading machinery and two large ones for the commodity carried. Each half of the car is equipped with a power-driven drag-chain conveyor which moves along the bottom from the end, pushing the

commodity loaded toward the center opening, then rising vertically to a sprocket at the top of the tank, whence it returns again to the end of the car. The conveyors can be operated very slowly. Two hours or less is given as the time required for loading.

Gyro-centric Roll Crusher's Simple

A new crusher, known as the "gyro-centric," has been developed by Patterson Foundry & Machine Company, East Liverpool, Ohio. It is shown in a cut. Having only three major parts, the case, the concave crusher plates, and the cylindrical crusher roll, its design is simple. The roll operates by a rapid gyro-centric motion against the stationary plates, giving two short strokes per revolution. Crushing capacity of the various sizes ranges from 15 to 25 tons per hour, making a ½-in. product, to 70 to 85 tons per hour when crushing to 1½ in. The crusher is intended for a wide variety of non-metallic and metallic materials and ores.



Dragline for Soft Ground

A new dragline (45) recently introduced by Bucyrus-Erie Company, South Milwaukee, Wis., has a long (19 ft. 6 in.) tapered caterpillar-type mounting which enables it to work on and to cross soft ground easily and without nosing in. The machine may be equipped with a 2- to 2¼-cu.yd. bucket (depending on the weight of the bucket, the material being handled, and the working radius) and a 50-ft. boom, or a 1¼- to 1½-cu.yd. bucket on a 65-ft. boom. Booms may be had up to 80 ft. long. The dragline is equipped with a 155-hp. six-cylinder engine.

Hose Coupling Acts Quickly

A cadmium-plated steel hose coupling (Type Q) of the snap-on type, which acts quickly and cannot come uncoupled, has been developed by the Cleveland Rock Drill Company, Cleveland, Ohio. Heat-treated alloy steel being used, the walls have been made thinner, which allows a large opening through the entire stem. Two sizes, ½ and ¾ in., are available.

Determining Wire-Rope Tension

An instrument for determining the tension on a wire line has been developed by the Martin-Decker Corporation, 3431 Cherry Ave., Long Beach, Calif. This is known as the shunt-type tension indicator. It operates on the principle of deflection and may be placed on any part of the line. It will then register the load on the line as well as any change or variation in load which takes place while upon it. It may be used on any stranded line within its range, as well as on solid copper and aluminum wire. The principle upon which it works is simple. A slight offset is made in the line between two fixed points. The pressure to make this offset is balanced by a fluid body behind a flexible diaphragm. This pressure is a direct measure of the load on the line. It becomes simply a force triangle with the line loads forming two sides, and the pressure exerted by the fluid, the other. The deflection is so slight that no permanent set or distortion of the line takes place. An instrument of this sort may be used to determine the tension on lines, on dredges, shovels, hoists, and the like.

Safety for the Welder

During welding some particles of molten rod are certain to spatter. In close work where the welder's head is brought near the job, this molten rod spatters the glass in the welder's helmet. For this reason, expensive colored glass, which enables the welder to watch and work without damaging his eyes, is protected by a piece of clear glass, placed in front of it, which takes the punishment. To remedy this and to add to the life of the clear glass, Ohio Brass Company is now coating the latter with a special preparation which minimizes the possibilities of the spattering rod sticking to it. As a result, the service of this glass is nearly doubled.

Dries and Separates at Same Time

A roller mill, equipped with air separation and air drying so that it operates as a kiln mill, has been introduced by Raymond Brothers Impact Pulverizer Company, Chicago. No auxiliaries are required. Drying is controlled thermostatically. For pulverizing combustible substances, such as sulphur, neutral gases such as CO_2 may be introduced into the mill instead of air. Capacity ranges up to 40 tons per hour.

Testing Wear and Lubricants

A machine for testing wear and lubricants has been developed by the Timken Roller Bearing Company, Canton, Ohio. It is said to be a simple, compact, and inexpensive mechanism by means of which may be ascertained the load-carrying capacity of lubricants, friction, and wear characteristics of any kind of material. Hitherto such testing has been possible only with complicated laboratory apparatus.

Leather Belting Practice Changed

Leather belting is now being sold on specifications of thickness instead of weight, the American Leather Belting Association has announced. The old weight terminology of "ounces per square foot" has been discarded. Protection of the consumer is said to be the objective.

INDUSTRIAL NOTES

Dust Recovering & Conveying Company, Cleveland, Ohio, has formed a foreign business department and adopted a policy of licensing foreign manufacturers in the principal industrial countries to build and sell, in their own territories, dust-collecting and pneumatic conveying equipment from their Dracco designs. For Great Britain and overseas dominions, except Canada, the company has become associated with the Power-Gas Corporation, Ltd., Stockton-on-Tees, England. It has also opened an office at 77 Rue des Tanneurs, Brussels, Belgium, under management of engineers of Tevo, Ltd.

Mancha Storage Battery Locomotive Company has sold its business, good will, and part of its assets to Goodman Manufacturing Company, Chicago, to which point the Mancha business will eventually be moved. The company will be operated as a separate organization under its old name.

Great Western Electro-Chemical Company, San Francisco, has published additions for 1931 to its index of literature on flotation.

Pittsburgh Equitable Meter Company and the Merco Nordstrom Valve Company have joined interests. The latter will be operated as a division of the former.

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BULLETINS

Wire Rope. MacWhyte Co., Kenosha, Wis. Booklet, wire rope for mining.

Bicable Ropeways. J. Pohlig, A. G., Cologne, Germany. Special Catalog 3108, in German.

Grinding Mills. Paul O. Abbe, Inc., Little Falls, N. J. Catalog N, ball and pebble mills and mixers.

Crushing and Screening. Smith Engineering Works, Milwaukee, Wis. Bulletin No. 262C; portable crushing and screening plants.

Circuit Breakers. Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. Circulars 1937 and 1939; De-ion circuit breakers.

Clarifiers. The Hardinge Co. Inc., York, Pa. Bulletin 38; clarifiers for sewage treatment, water purification, and industrial waste treatment.

Monocable Ropeways. J. Pohlig, A. G., Cologne, Germany. Catalog 3201, in German, English, French, and Spanish. Details of all types of installations.

Mechanical Handling. J. Pohlig, A. G., Cologne, Germany. General Catalog No. 3111 E, in English, describing all types of transport, conveying, and loading equipment.

Refractories—E. J. Lavino & Co., Bullitt Building, Philadelphia, Pa. Bulletin No. 1-13-15, improved Lavino chrome brick (new process) vs. the best chrome brick (usual process).

NEWS OF THE INDUSTRY

UNITED STATES

San Francisco, April 27

Placer Mining Active. Banks of Chico, Calif., are reported to be receiving from $7,500 to $8,000 worth of gold per month from placer mines and prospects in Butte County. Individual quantities range from 50c. up to as high as $800, the latter from placer operations where more or less equipment is employed. The smaller amounts come from pannings upon creek and river beds.

Seymour Placers, on the East Fork of Coffee Creek, Trinity County, was recently sold to C. E. Carr at a sheriff's sale. Salmon River placer mines in the Cecilville district are working full time. The Westover, Brown, Banner, George Brothers', Jefferson Consolidated, McBrown and Farnsworth properties in this district are being operated. Salyer Placers, Inc., in Trinity County, is operating two hydraulic giants. Preliminary work is under way by the United Placers, Inc., at its Canyon Creek property above Junction City.

Bangor Gold Mining Company, southeast of Oroville, has been leased to R. Young and D. Wright and an old shaft is to be deepened to the channel when drifting is to be started. Additional mill equipment is being installed at the Empire cyanide plant near Grass Valley preparatory to the treatment of concentrates from the Murchie Mine. At the Estelle property near Keeler, controlled by A. S. & R., active development is in progress with about 30 men employed.

Alaska Juneau reports 306,870 tons mined and trammed to mill in March, from which estimated results were as follows: Operating revenue, $240,500, or 78.37c. per ton; operating expenditures, $178,500, or 58.17c. per ton; operating profit, $62,000, or 20.20c. per ton; interest received less cost of outside prospecting was $2,700, leaving $64,700 to surplus for the month.

The Boswell Group of claims near Middletown, east of Redding, Calif., has been bonded to F. A. Zimmerman. The McLain placer property west of Magalia has been sold to L. Gage and T. Young.

Indian Hill hydraulic property near Downieville has washed 50,000 yd. of top gravel and bottom gravel is being piped. Water for six weeks is available.

Debris storage at the Bullard's Bar dam has been decreased from 3 to 2c. per cubic yard by the Pacific Gas & Electric Company, and this reduction is expected to stimulate placer mining on the Yuba River. Pine Tree Exploration has started operations upon its placer holdings near Magalia.

Banner Mine, northeast of Oroville, in Butte County, long unworked, is reported to have been sold to C. Low, F. Irving, H. S. Smith and others.

Empire Star to Resume. Preparations are being made to resume production at the Murchie mine by the Empire Star. The mill has been reconditioned and the shaft repaired.

Gray Wing Developing. A gravel channel area between Folsom and Mormon Island near the American River is to be test-drilled by Gray Wing Extension Mining preliminary to shaft sinking and drift mining. The area of 450 acres is on the Broder estate. The Gray Wing and the Old Channel mines, both drift properties, were at one time worked upon a portion of the channel. E. R. Gray and J. W. Howard have leased the property upon a royalty basis.

Tom Boy drift property near San Andreas is being explored. The Lamphier property north of the Tom Boy is being unwatered and is to be explored. Work is also in progress at the Safe Deposit and Easy Bird.

Lisbon Mine, in the Mammoth district west of Bishop, has been taken over by the Nucleus Syndicate headed by N. M. Simmons.

Amalia's Property near Amalia, northeast of Caliente, has been acquired by S. Riess and associates. A power line is to be constructed, the old shaft unwatered and shaft sinking is to be started.

American Clay is constructing a 1,000-ton clay storage building in Los Angeles. Clay is obtained from Jaw-Bone Canyon at Cantil.

Central Eureka Mining is now operating twenty stamps at its property near Sutter Creek.

Adams Mining is planning to operate a ten-stamp mill at its property, formerly called the Buchanan, near Indian Valley, Plumas County, early in May.

Obra Mines Corporation is reported to have completed arrangements to bond the Rainbow Extension claims in the Alleghany District.

Placer Properties controlled by J. D. Stewart, in the Gold Run-Dutch Flat district, have been bonded to F. P. Fogg, N. Douglas, and J. C. Anderson. Plans to work the claims by power shovels are under consideration.

Granite Quarries near Rocklin, Calif., are to be reopened in the near future and granite for government buildings is to be quarried. Four quarries are reported to be in operation.

Walker Adds to Ore. Development work was maintained at the Walker Copper mine in 1931, despite curtailed production. Ore reserves have been considerably increased. The mine is now closed down, but J. R. Walker, president, states that it is in as good condition as at any time in its history.

Beebe property's lower workings near Placerville are being unwatered and mill construction has been advanced.

Leasers at the Yellow Aster property near Randsburg are keeping 50 stamps in operation. At the Kelly property a substantial tonnage is being milled. Leasers and prospects in the district are active. At Summit Diggins placer ground is being sluiced by water pumped from a well. Near Barstow, Western Chemical is preparing to work an alum deposit.

California "Tech" Offers Scholarships. Freshman prize scholarships will be offered next year by the California Institute of Technology at Pasadena. They are to be awarded on the basis of a broad scholastic competition and of personal qualities to students interested in scientific or engineering education. The purpose of the offer is not to increase the size of the student body, whose freshman class is limited to 160 men, but to draw to the institution students from a wider area than formerly. High schools of the different sections of the country are to be asked to recommend worthy students. New student houses, recently completed, provide attractive living conditions for the student body.

New York, April 20

Limerock in unusual amounts has been discovered near Perry, Fla.

Braden Reserves Down. As no development work was done during 1931 at the Braden Copper property, near Rancagua, Chile, ore reserves at the property decreased by approximately the tonnage mined (except for an adjustment due to overextraction from some blocks) to 225,996,000 tons averaging 2.18 per cent copper. Metallurgical results showed a recovery of 86 per cent of the copper content.

Inspiration Costs Low. Despite curtailed production, Inspiration Consolidated last year cut its operating costs, including depreciation, to 8.4288c. per pound, the lowest recorded in the property's history. Except for a small tonnage of high-sulphide ore for which the mill had to be operated, the entire production of the mine was put through the leaching plant. The company was forced to borrow $3,600,000 to retire its bond issue due in 1931, refunding being impossible because of bad financial conditions prevailing.

Butte, Mont., April 28

Big Belt Gold is producing placer gold from Magpie Gulch, near Helena.

Gold Star has arranged for the erection of a 50-ton ball mill at the company's property south of Missoula. The

mill will be built by the Union Iron Works.

Three Large Labor Organizations of Anaconda, the Mill and Smeltermen's union, the Anaconda Metal Trade Council, and the Central Labor Council, have acted to secure representation before the state supreme court in the suit to force the state board of equalization to make a reassessment of the metal mines tax.

Hidden Treasure Group, the Keith & Bieber property, in the McCarthy Mountains, near Glen, Madison County, has been acquired by Frederick C. Gilbert, Butte mining engineer. The property has produced quite a tonnage of high grade gold ore, part of which has been milled in a small plant at the mine. Mr. Gilbert, who formerly was with the American Smelting & Refining Company, in Colorado, plans to enlarge operations.

Empire Gold Mines will soon be incorporated to take over and operate the Empire, Whippoorwill, and Smithville group of twenty claims on the west flank of Belmont Mountain in the Marysville mining district, Lewis & Clark County. These properties have a production record of close to $3,000,000 in gold and the camp record is $58,000,000, practically all gold. The properties are well equipped with mining machinery and camp and mill buildings.

Libby Mountain group of placer and quartz claims, near Libby, has been taken over by Dr. D. M. Kelly, of Milwaukee and associates. Operations will start soon.

Callahan Gold Mining, east of Jefferson City, Jefferson County, is installing mining and milling equipment and carrying on mining operations.

The Dunn claims, near Moose Lake, Granite County, have been acquired by William G. Leamon, of Chicago and Los Angeles. Mine developments will start soon. The property has produced high-grade gold ore in the past.

Transfer of Public Domain. Legislation is pending in Congress that proposes to turn over to the Public Land States the remnant of the public domain within their borders, involving (1) a severance of surface and subsurface rights, the former being conveyed to the states and the latter being reserved to the United States; and (2) conveyance of surface and mineral rights to the states. The Montana Section of the A.I.M.E. has recently gone on record in stating that, so far as known, no desire has been expressed by the mining industry for such transfer, maintaining that, under the first proposal, a discouragement of prospecting and a confusion of title would result, together with virtual abrogation of established legal procedure governing possession and operation of mineral rights. Under the second proposal, the Montana section maintains that the minerals would be placed under the jurisdiction of the State Land Boards, all of whom are committed to the collection of royalty on state-owned mineral; so that the result, in the case of mineral discovered subsequent to such transfer, would impose an additional tax. The Montana Section therefore is opposed to the enactment of either measure. It insists that discovery and development of mineral resources will be best assured if the unappropriated lands remain in the possession of the Federal Government as trustees, in order that mineral deposits contained therein may continue, in the words of the statute, "to be free and open to exploration . . . and the lands in which they are found to be open to occupation and purchase by citizens of the United States and those who have declared their intention to become such."

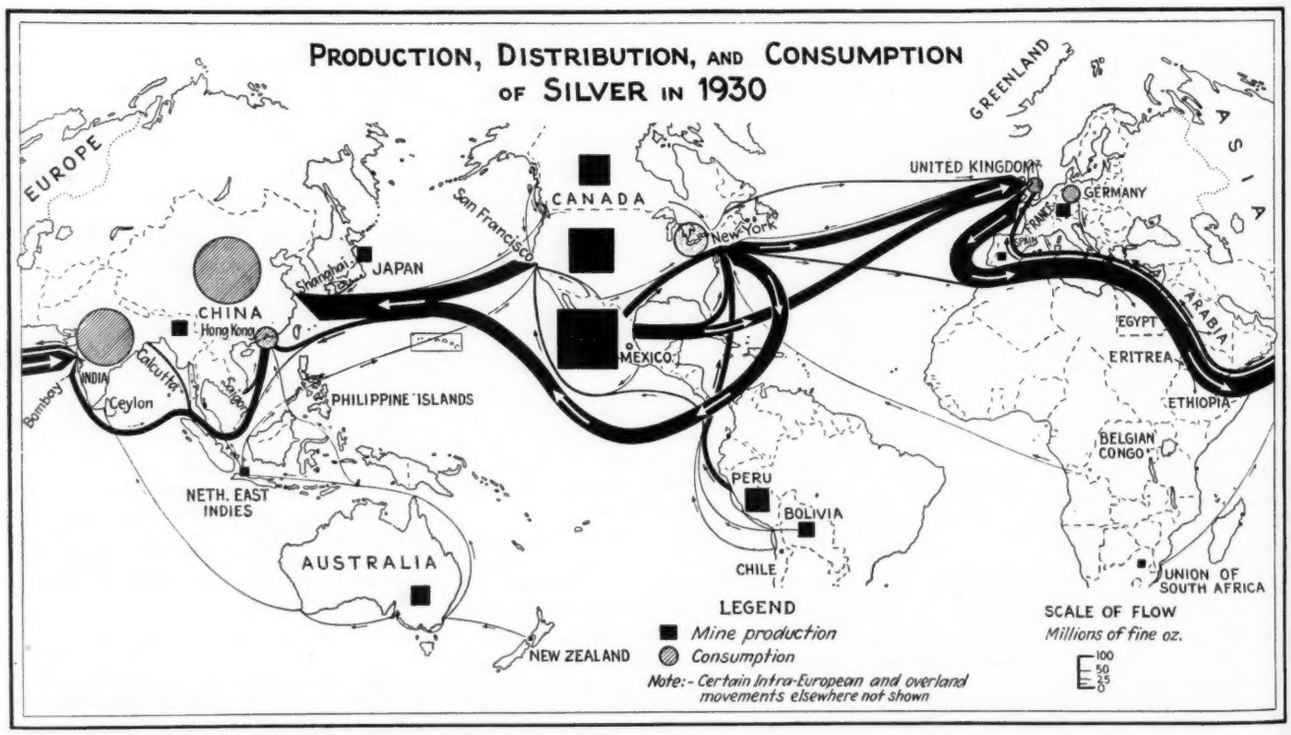
Miami, Ariz., April 24

Miami Copper, under date of April 12, has made the following announcement:

"Since the break in the copper market in 1930 the Miami Copper Company has continued to operate at a heavy loss in an effort to maintain its organization and property as a going concern. It had been hoped that by this time better conditions in the copper industry would have arrived or at least would be in sight. This has failed to materialize. Under these conditions the company is unable to continue to carry on its present operations in its low-grade sulphide orebody and regrets to announce that during the second half of next month these operations will be closed down. All employees will please consider this announcement as a one month's notice of discontinuance of employment and those who may be retained under the reduced scale of operations will be notified."

Tom Reed gold mine and mill at Oatman, Ariz., were closed down on March 19. The company has not announced the reason for the shutdown nor its duration. Near the Vulture mine, at Wickenburg, the Texona Mining Company has completed the sinking of a 500-ft. shaft and has done about 500 ft. of drifting from the bottom of the shaft. F. E. Calkins has just completed a geological examination of the property. West of the Vulture the Vulture West Extension has an inclined shaft down 140 ft. along a mineralized contact between granite porphyry and schist. Some gold-bearing quartz has been encountered. The property is controlled by Wenden Copper.

Arizona Magma Mining Company is to erect a 50-ton mill at its Diana property near Chloride. C. A. Kumke, formerly with Ray Consolidated, has been



Abstract reproduction of chart by H. M. Bratter in "Commerce Reports," April 11, 1932, Bureau of Foreign and Domestic Commerce, United States Department of Commerce.

appointed mine superintendent. Fifty men are on the company's payroll.

El Tigre Mining of Mexico has purchased some claims in the Oro Blanco district near Tucson and has installed a compressor for use in developing them. Leslie C. Moore and associates are erecting some buildings on their property in the same district in preparation for starting exploration work.

Student Geologists of the Arizona College of Mines have announced a discovery of gold south of the Superstition Mountains. A gold rush is reported in progress.

National Explorations will install new equipment, consisting of a Blake and Symons crushers, Marcy ball mills, and Dorr classifiers and tables.

Alvarado, an old property in the southern part of Yavapai County, has been re-leased and will be operated by an Oregon syndicate.

Consolidated Gold's Lexington shaft is developing an occurrence of andesite and quartz similar to that found in the Town Reed and United Eastern mines.

Salt Lake City, Utah, April 27

A New Merger. Plans are being made to merge the Star of Utah, the Park Galena, and the Mayflower properties at Park City. A new company with 3,500,000 shares will be formed and exchange of stock will be on a basis of one share of Star of Utah for one of the new, four shares of Mayflower for five of the new, and Park Galena, one share for two shares. An assessment of 10c. a share will be levied on new stock.

Full-Time Operation of two lead furnaces was resumed April 16 by the International Smelting Company at Tooele, Utah. Employees will be employed on the basis of one-third time per man. Operations are said to be assured for two and a half to three months.

North Lily-Knight properties, in the East Tintic district, including the Big Hill and the Eureka Bullion, have suspended work. Two headings will be continued in the North Lily group, one in the Tintic Bullion and the other in the Baltimore group, leased from the Chief Consolidated.

International Smelting is advancing its tunnel steadily in the Sacramento Gold and Quicksilver property at Mercur, to attain depth on a low-grade tonnage opened in the upper workings

Utah Adds to Ore. Some extensions of the orebody were indicated by churn drilling at the Utah Copper property, Bingham, Utah, during 1931, but the ore developed thereby has not been estimated, the annual report states. Only one of the company's mills was operated —the Magna plant, averaging 22,508 tons daily. Mining cost per ton was 39.57 cents; milling cost, 39.27 cents; and total costs, including ore delivery, 90 cents. Cost per pound of copper was 6.59 cents, exclusive of depreciation.

Reno, Nev., April 27

Bullion Tax Payers for 1931 in Nevada will be only a few gold companies. Elkoro Mines leads with a report for the last half of 1931, showing gross production of $273,946, with deductions of $190,005, leaving a net of $83,942. Then comes the Bradshaw, Inc., operating the tailings pond of the Goldfield Consolidated, with a gross of $151,018 and deductions of $100,541, a net of $50,496. Goldfield Consolidated reports receipts from royalties on Nevada properties of $11,230, deductions, $1,111, net, $10,119.70. Tonopah Mining, which has in times past been a heavy bullion tax payer, reports a net of only $4,038. Treadwell Yukon reports gross, $318,-246, deductions $340,888—a heavy loss.

Gold Mines of Nevada, particularly those of the southern part of the state, show every indication of largely increased production for 1932. Leasers on Goldfield properties give promise of greater activity and two or three may come into production on company account. For the first season in years Round Mountain will have an abundant water supply. This means that both placer and quartz properties will be worked to the limit.

Copper Canyon is developing into a gold camp under the management of J. C. Brumblay, also Nevada agent for the International Smelter. Copper Canyon Mining Company was started as a copper producer, shipping some rich copper ore. On taking charge of the work about two years ago Mr. Brumblay discovered that several shear zones that cut the quartzite reef at right angles carried gold. Exploration of these zones was begun, and gold ore shipments have been going out ever since.

Grubstaking Unemployment. Plans are being discussed in Reno looking to the incorporation of a company that will serve as a sort of grubstake for graduating engineers from the Mackay School of Mines of the University of Nevada. The plan is to raise capital to take over a property or a lease on proven ground and put a number of the young graduates who have not made employment connection with other companies. They will be in charge of an experienced mining engineer. Another group will be sent out prospecting in charge of an engineer or a well-known prospector.

A Concentrator, with a washing capacity of 4 cu.yd. per hour, is being installed in Limerick Canyon by the Security Reserve Mining Corporation. It is of the Hullsdonk type.

Gold Circle Consolidated is moving its power plant to a central point in the Midas camp, from which power will be furnished to the mill and pumps at the Elko Prince mine. The plant includes a 150-hp. engine and one 120-hp. Fairbanks-Morse Diesel engine. Elko Prince shaft will be continued from the 750 level to the 1,200.

Seven Troughs Gold Mine, at Lovelock, has been renamed the Nevada States Gold Mines Company. The property has been refinanced.

Nevada-Massachusetts tungsten mill, near Mill City, in Pershing County, is operating on two shifts, a third shift having been discontinued recently. Mill capacity is 30 tons of high-grade tungsten concentrate per month, from scheelite ore.

New Tonopah Divide Mining will build a washing plant at its gold placers in the Lynx Creek district of Arizona. The plant will have a capacity of 2,500 cu.yd. of gravel.

White Caps mine, at Manhattan, has resumed shipments of gold ore, the product going to Utah smelters.

Black Mountain is shipping from its property at Silver Peak, to the Garfield Smelter, in Utah.

Annual Reports of Mining Company Earnings

Company	Product	Location	Operating Profit	Net Profit	Net Profit Previous Year	Value Output	Dividends
Amparo Mining	Silver, gold	Mexico	—$2,693	—$43,553	—$74,027	$435,484	None
Anaconda Copper	Copper, zinc	Various	$6,409,427	—$3,151,727	$18,782,968	$96,387,706	$6,680,657
Chile Copper	Copper	Chile	$4,301,761	$518,509	$8,250,905	$10,966,614	$5,519,379
Consolidated M. & S.	Lead, zinc	Canada	*a*	—$713,290	$2,755,317	$15,670,946	$2,748,421
Dome Mines	Gold	Canada	$1,871,746	$1,690,825	$117,895	$3,486,506	$953,334
Great Northern Iron	Iron ore	United States	$2,533,546	$2,122,500	$3,084,763	(*a*)	$3,000,000
Hudson Bay M. & S.	Copper, gold, zinc	Canada	$1,029,928	—$301,947	$2,916	$5,401,313	None
Inspiration Cons.	Copper	United States	$79,828	—$492,522	$273,759	$3,609,983	None
Kennecott	Copper	United States, Chile	$7,790,890	$3,848,828	$15,585,737	$48,501,416	$10,568,829
Kirkland Lake Gold	Gold	Canada	$227,131	$203,051	$74,490	$615,882	None
Lucky Tiger	Silver, gold	Mexico	—$6,417	$4,287	—$8,209	$347,933	$99,254
Miami Copper	Copper	United States	—$626,139	—$885,759	$726,713	$4,394,231	None
Nevada Consolidated	Copper, gold	United States	—$2,129,651	—$2,060,669	$1,860,733	$9,879,150	$3,885,798
North Lily	Lead, gold	United States	$46,998	$47,039	$160,783	$252,554	None
Rio Tinto	Copper, pyrites	Spain	£424,894	£100,185	(*a*)	(*a*)	£81,250
St. John del Rey	Gold	Brazil	£142,292	(*a*)	£124,423*b*	£519,691	£83,970
Societe des Minerais	Holding	Various	5,014,463 fr.	1,059,074 fr.	(*a*)	(*a*)	None
Tennessee Corp.	Copper, pyrites	United States	$467,149	$5,366	$1,034,907	$7,572,760	$214,454
Treadwell Yukon	Gold, zinc, silver, lead	United States, Canada	—$34,435	—$870,449	—$1,317,664	$2,038,795	None
Utah Copper	Copper, gold	United States	$698,153	$2,027,149	$8,889,381	$11,548,245	$9,746,940
Walker Mining	Copper, gold	United States	—$73,829	—$116,072	$276,232	$982,090	None

(*a*) Not available.
(*b*) Operating profits in 1930.
In general, the figures for operating profit (or loss) represent the balance after deducting cash expenditures from the value of production. The figures for net profit (or loss) include the addition of sundry income, and the deduction of charges for depreciation, taxes, or other extraordinary expenditures. Because of the difference in accounting methods of different countries and different companies, the figures are not strictly comparable.

Elkoro, Nevada's biggest gold mine, produced, in 1931, $530,398, principally in gold. It also increased its holdings in the Jarbidge district. Elkoro is a subsidiary of Yukon Gold.

Castle Peak quicksilver property, 19 miles south and east of Reno, will soon resume after a six-month shutdown. It has a capacity of from 110 to 120 flasks monthly.

New Comstock Mining Company has recently been incorporated to operate properties in Ramsey, Lyon County. Capitalization is $1,500,000.

Chollar, Gould & Curry, and **Savage** mining companies have initiated a vigorous campaign of prospecting in the American flat area of the Comstock Lode, uniting their resources. These companies have installed a powerful electric hoist, a compressor, and other machinery at Overman shaft, and are crosscutting from the 1,100 ft. level.

New Comstock Mining Company has been formed in Reno to operate the Ramsey Comstock and other gold mines in the Ramsey district near Virginia City. It is capitalized at $1,500,000. The district is about 15 miles northeast of the Comstock Lode, the greatest mineral area ever found in Nevada.

Emma Mine, an old property in Whitehorse Canyon, northeast of Wadsworth, has been leased by the Champion Whitehorse Mines Company to Parker Riddell, of Reno.

Auburn Mine, in the Dun Glen district, has been optioned to Eastern capitalists.

Alaska States Corporation has filed articles of incorporation at the State Capital, Carson City. Capitalization is given as $5,000,000. Reno investors are sponsoring the company, which will specialize in development and mining.

Wallace, Idaho, April 26

Granado Lead has resumed development near this city.

Golden Anchor, in the Marshall Lake district, near Burgdorf, acquired some years ago by United Verde Extension, will be developed by U. V. Ex. this season in the course of the company's exploration campaign at the property.

Hibbing, Minn., April 26

Ahmeek Mine, of Calumet & Hecla, closed on May 1. The conglomerate shafts will be the only units of the C. & H. group to operate under existing conditions.

Oglebay Norton Company, of Cleveland, having completed its two-year contract with the Soviet Government, has withdrawn from Russia. The engineers of the staff were offered new contracts, but the terms were unsatisfactory.

Isle Royale Mine, which is under Calumet & Hecla management, will be closed May 1, along with Ahmeek, of Calumet & Hecla, until the copper market warrants reopening. Isle Royale's cost per pound in 1931 was 11.48c. not including depreciation and depletion. Operating loss for the year was $255,-571.74.

The **Copper Range,** in the Michigan Copper district, will undergo no change of policy May 1, and will continue operations on the present basis. Production is down to 1,000,000 lb. per month. Only Champion is being worked.

Hull-Rust on Four-Day Basis. Until some decision is made by the village council regarding the closing of the Penobscot road, the Hull-Rust mine will only work four days a week instead of six.

St. Louis, Mo., April 18

The Fourteenth Annual Meeting of the American Zinc Institute was held in St. Louis April 18-20. Ralph M. Roosevelt, vice-president of the Eagle-Picher Lead Company, was reelected president; A. P. Cobb, J. O. Elton, and John A. Robinson were reelected vice-presidents; Howard I. Young was elected treasurer; and Julian D. Conover, secretary.

"Recent Developments in Zinc Die Casting" was the subject of a paper presented by W. N. Peirce, chief of the metal research division, The New Jersey Zinc Company. Among other papers presented at the meeting were "Review of World Zinc Conditions," by Oliver Roskill, London, England; "Eagle-Picher's Central Milling Project in the Tri-State District," by R. J. Stroup, Eagle-Picher Mining & Smelting Company; "The Metaline Falls Zinc Mining District," by L. P. Larsen; "Sprayed Metallic Coatings," by L. E. Kunkler and R. E. Axline; "A New Viewpoint on the Sherman Anti-Trust Law," by Barnabas Bryan, Jr.; "Traffic Problems in the Zinc Industry," by A. J. Bien; "Technical Studies of Zinc-Coated Materials," by G. C. Bartells; "Telling the Story of Heavy-Coated Sheets," K. J. T. Ekblaw; "Selling the 'Seal of Quality' in the Field," by Charles Matthews; "The Dealer's Viewpoint," by Charles A. Kiefner; "Progress in the Roasting of Zinc Ores," by R. E. Rowen; "The Waelz Process," by William E. Harris; "Progress Report on Methane Reduction of Zinc Ores," by R. S. Dean; "Recent Developments in Electrolytic Zinc," by Arthur Zentner; and "Progress Report on Experimental Study of Embrittlement in Galvanized Structural Steel," by S. Epstein.

Houston, Tex., April 29

Great Permian Basis, in Texas and New Mexico, has disclosed a supply of potash sufficient to fill the country's needs through any emergency which may arise in the future, according to the U. S. Geological Survey. One year's working by the United States Potash Company, of New Mexico, developed 45,000 tons of potash, or about 4 per cent of all the nation's requirements.

Salt Lake City, April 24

International Smelting recently resumed full-time operation of two lead furnaces at Tooele, thus effecting a material increase in the number of men employed. The company has accumulated sufficient ore to provide for three months' operation on a part-time basis.

Spokane, Wash., April 26

Pend Oreille Mines & Metals set a new monthly record in its Josephine mill in March, when 1,500 tons of concentrates were produced. Of this, 1,250 tons were sinc and 250 tons lead.

Ole Mining has resumed operations in the Hog Heaven silver mining district and will attempt to uncover a body of ore large enough to warrant regular shipments to the smelter at Kellogg, Idaho. A shipment last fall yielded nearly $60 per ton in silver, gold, and copper.

Central Idaho, in both placer and lode, promises much for the coming year, for the dual reason that gold is relatively worth more than for many years, and many mining districts formerly isolated are now accessible because of highway construction. Western Montana is another gold district attracting many mining men from Spokane and the Northwest. The Sheep Creek gold district, just across the northern boundary of Washington, is the most active region in the Kootenays, and the old Republic camp, in Washington, and the Murray district in the Coeur d'Alenes are both producing gold. The Metaline district, where zinc is the chief ore, promises most of all this year, largely because of the active development in progress, and the lead-silver mines of the Coeur d'Alenes, even in spite of low prices in those metals, are carrying on as usual.

Juneau, Alaska, April 14

Nabesna Gold expects to have its new mill in operation in May of this year.

Eva Creek Mining, at Ferry, has resumed on full time. Smelter shipments of concentrate are estimated at four carloads per month.

Prospecting during the open season of 1932 in the territory will be especially active. A good production is expected from the Kongarok diggings. Increased Lode Gold production in Alaska is predicted in an official report of the U. S. Geological Survey.

Platinum-bearing Sands are reported to have been discovered on Chirikof Island, in the North Pacific.

Denver, Colo., April 20

Vocational Panning Course. The panning of gold has been placed on a scientific basis by the Pueblo (Colo.) public school vocational department. A course in the art has been started with 180 "students" under tutelage of three competent instructors.

Washington, D. C., May 2

George Otis Smith's appointment by President Hoover to the chairmanship of the Federal Power Commission was confirmed today by the United States Supreme Court, to which the issue had been referred because of an attempt by the Senate to recall the confirmation of Dr. Smith after he had been accepted by the Senate and had taken his oath of office. The opinion of the Supreme Court was unanimous. It was delivered by Justice Louis D. Brandeis.

Richmond, Va., April 20

The **Crimora Manganese** property, in Augusta County, has been sold to Western interests. G. S. Rosenberger and Marshal Haney represented the vendors. The names of the purchasers and the consideration involved have not been made public.

CANADA

Sudbury, Ont., April 30

Thunder Bay District, for years dormant so far as mining activity was concerned, entered the production columns in April with the pouring of $11,952 in gold bullion at the Moss Gold mine. This is Ontario's newest producer. About 80 men are employed.

Falconbridge Nickel, by the installation of a new 200-hp. G.E. motor, has increased its hoisting speed from the 1,000 level to between 600 and 1,000 ft. per minute. Developments at the 350-ft. level have revealed unexpected widths and grade of ore. Mine and smelter continue to operate at capacity on a basis of about 375 tons of ore daily.

Lake Shore Gold, at Kirkland Lake, has carried its workings to a depth of 3,075 ft., with plans under consideration for extending No. 3 shaft to a depth of 3,950 ft., allowing eight new levels to be opened up at intervals of 125 ft. The program calls for extension of shaft facilities another 1,000 ft., and eventually to the 8,000 level. This will necessitate the installation of underground hoisting facilities and the provison of a new host at the 4,000-ft. surface duplicating the present surface equipment.

Mining Corporation of Canada has emptied Cobalt Lake of approximately 1,500,000 gal. of water and about 400,000 tons of slimes by means of a crater blasted in the bed of the lake for the purpose of exposing a silver vein from which about 300 tons of high-grade ore will be removed. The blast required 100 lb. of dynamite and left a hole 800 ft. across at one point with a maximum depth of 45 ft. The water and slimes were allowed to pour into the mine, filling it to a depth of 50 ft.

International Nickel has completed the reconditioning and equipping of No. 4 shaft of the Frood mine, on the former Mond section of the property at Sudbury. A new Nordberg hoist, a duplicate of No. 3 shaft equipment, has been installed and first rock from the No. 4 area will be hoisted some time in May. A series of raises for ventilation purposes in No. 4 shaft area have been completed and will become part of the elaborate ventilation system of the mine.

Vancouver, B. C., April 26

Treadwell Yukon has found a new mine in the Bussiere of the Pascalis district, province of Quebec, Canada. A new strike of placer gold is reported on McConnell Creek and the Ingeneka River, in British Columbia. M. J. Brown, a veteran prospector, is principally interested. The property is operated on an individual ownership basis.

Reno Gold Mines, Ltd., operating near Nelson, B. C., recently completed the purchase of the adjoining Motherlode and Nugget properties, including the Motherlode mill, having a daily capacity of 100 tons, and the waterpower plant, from the liquidator of the Stobie-Furlong Company.

Wernecke Near Exhaustion. High-grade silver ore at the Wernecke unit of Treadwell Yukon, near Mayo, Y. T., will be exhausted this summer. Unless the price of silver improves or new ore is found, the mines will have to close.

Toronto, Ont., April 28

Canadian Industries, Ltd., is designing a commercial plant to be built at Copper Cliff, Ont., to produce sodium and aluminum sulphates. These chemicals are to be recovered from waste slag by a new process developed by Canadian Industries. A sufficient quantity of slag is produced at the International Nickel mine to allow approximately 15,000 tons of sodium sulphate and 25,000 tons of aluminum sulphate to be reclaimed annually.

Canada Radium Mines, Ltd., is preparing for the production of radium on its property near Wilberforce, in Haliburton County, Ont. A complete mining plant with equipment for development to 1,000 ft. has been purchased and shipped to the property.

Hudson Bay Copper Operations. At the annual meeting of Hudson Bay Mining & Smelting Company, held recently in Toronto, R. H. Channing, Jr., president, stated that the board had not even considered closing down its copper property. Gold content in the ore, he said, was holding constant. Though income was naturally reduced through the drop in the price of copper, all copper production had been sold.

Howe Sound Production. Howe Sound Company, operating in Mexico and British Columbia, produced 22,232,713 lb. of lead, 3,163,129 lb. of zinc, 2,205,318 lb. of copper, 795,704 oz. of silver, and 589 oz. of gold in the first quarter of the year.

MEXICO

Mexico City, April 26

Lane-Rincon Mines is planning enlargement of its flotation unit at its Rincon mine, near Toluca, capital of Mexico state. The enterprise now employs 550 men, 300 of whom are miners. A shaft has been sunk 520 ft. and about 100 tons of silver ore are being handled daily.

Cananea Consolidated Copper, at Cananea, Sonora State, is employing about 1,000 workers and 1,000 tons of copper ore are being treated daily.

Dos Estrellas Mining is working in only one region, on the border of Michoacan and Mexico states. It has two operations, the Dos Estrellas mine in the former state and the Esperanza mine in the latter. Both mines are connected underground and the combined ore output is handled at the company's mill at Mineral de Dos Estrellas, Michoacan State.

A new gold strike is reported at Los Lugos gold mine, near Guadalajara. The property is owned by residents of the Northwest, its head office being in the Stock Exchange Bldg., Spokane, Wash.

Lucky Tiger Reserves at Ebb. Ore reserves of Luck Tiger-Combination at its silver-gold mine in northern Sonora were down to 9,845 tons at the end of 1931, or about five months' reserves at the low rate of production now prevailing. This mine has produced a total of 314,880 oz. of gold and 57,925,499 oz. of silver, but its end is evidently in sight. The company has options on two gold properties in the United States that look promising—the Buckskin, near Winnemucca, Nev., and the White Gold, Santa Cruz County, Ariz.

Amparo to Continue. Despite the low price of silver, operating costs at the Amparo mines in Jalisco have been cut so that it is possible to operate without a loss by mining high-grade ore. Production in 1931 was at a curtailed rate, however. The properties in Guanajuato, known as San Nicolas del Monte, which Amparo is exploring, shipped a few hundred tons of high-grade ore in 1931 and effort is being made to block out sufficient mill-grade material to warrant erection of a plant there.

ENGLAND

London, April 22

Anglo Burma Tin. All of the new plant has arrived on the property, and everything is expected to be in readiness for starting up when the wet season sets in in May.

Mount Isa reports that the increase of the smelter capacity to 6,000 tons should be completed by Aug. 1.

New Guinea Goldfields mill should be ready to start in July.

Patiño Mines & Enterprises for 1931 shows a loss from mine operations of £114,642. There was, however, a profit on the working of the Machacamarca-Uncia Railroad of £27,336, thus reducing the year's loss to £87,305.

London Tin Corporation's Nigerian interests have been transferred to the London Nigerian Tin Mines, of which the corporation holds the capital.

Mining Company Dividends for April, 1932

Companies in the United States	Situation	Per Share	Total Disbursements
Aluminum Company of America, pfd	Various	$0.75Q	$1,107,475
Bunker Hill & Sullivan M'n'g & Conc'trat'g., pfd.	Idaho	2.00QX	12,775
Granite Gold Mining	Colorado	0.01Q	16,005
Homestake Mining	So. Dakota	0.65M	163,254
Magma Copper Co	Arizona	0.125Q	51,020
U. S. Smelting, Refining & Mining	Various	0.25Q	121,587
U. S. Smelting, Refining & Mining, pfd	Various	0.875Q	425,557
Companies in Other Countries			
Dome Mines, Ltd	Canada	0.25Q	238,333
Hollinger Consolidated Gold Mines	Canada	0.05Q	246,000
Howe Sound Co	Canada, Mexico	0.25Q	124,010
Lucky Tiger-Combination Gold	Mexico	0.03Q	21,460
N. Y. & Honduras Rosario	Honduras	0.25QX	100,000
Pioneer Gold Mines	Canada	0.03Q	(a) 50,000
Premier Gold	Canada	0.03Q	150,000
Wright-Hargreaves	Canada	0.025Q	137,500

(a) Payable in Canadian funds.

British Tin Investment Corporation, Ltd., has been registered as a public company with a nominal capital of £1,250,000 in 10/- shares, the objects being to acquire by purchase part of the undertaking of the British American Tin Corporation to carry on investment and trust business and to acquire mining concessions or mines.

Kafue Copper Development (India) announces that the Burma Government has granted to the company a prospecting license over the Inwedaw gold area, covering one square mile, below Kalaw and within a mile of the Southern Shore Railway. E. C. Garrett, formerly with John Taylor & Sons, reports favorably.

Boliden Not Nationalized. Since the death of Ivar Kreuger, a rumor that the Swedish Government would take over the Boliden mine (Sweden) has been officially denied.

Progress at Wiluna Gold. Important developments have been reported by Wiluna Gold (Western Australia). The East lode, which had previously given disappointing results northward, is showing better values to the south. The new No. 2 West lode is proving an important orebody. Its length so far is 100 ft. On the 625 level a crosscut at 342 ft. north exposed ore averaging £4.3s. over 14 ft. 9 in. Analyses show the ore to be typical arsenical and iron sulphide ore, free of antimony.

Rio Tinto's 59th annual report, presented at a meeting of the proprietors of the company held recently at Southern House, in addition to the finance statement, which appears elsewhere in this issue, disclosed the fact that though drastic economies have been effected in every department, these were largely neutralized by the maintenance in employment of large numbers of Spanish workmen, for whom the government could not find work elsewhere. The report says, also, "The situation is further aggravated by the increase of taxation demands. Cash amounting to over £800,000 was paid in taxation during the past year, more than half of which was required to meet the taxes imposed by the Spanish Government."

East Pool & Agar (Cornwall) accounts for 1931 show a loss of £7,245, which brings total to debit of profit and loss to £17,421. Operations were restricted to one shift per day throughout the year.

Ashanti Goldfields (West Africa) in February made net profit (excluding premium on gold) of £35,393, or with premium, £55,947. This compares with £58,209 (including £23,211 premium) for January. Developments are taking place in an impoverished zone, and assays for the month were all unpayable.

AFRICA

Johannesburg, March 30

The premium on gold production in Rhodesia has stimulated prospecting in Matabeleland and Mashonaland. A proposal by the government of Southern Rhodesia to tax the premium has aroused protest.

The Kilembe copper mine, in the foothills of the Ruwenzori Range, Uganda, which is owned by Tanganyika Concessions, is being developed.

A currency bill recently introduced for the Union of South Africa provides that the denomination of the new units shall be florins and cents, a cent being one-hundredth of a florin. The specie currency shall comprise a 10-florin gold piece, to be called a "rand," a double-florin silver piece, a single-florin silver piece, and fifty-, twenty-, and ten-cent silver pieces. Bronze coins will comprice four-cent, two-cent, and one-cent pieces.

Rhokana Starts Smelting. At N'Kana mine, of Rhokana, the concentrating mill started operations on Dec. 11, 1931, and has been in successful operation ever since. The metallurgical results obtained are satisfactory and the tonnage capacity is considerably greater than nominal capacity. Smelting operations started on March 17, 1932. The smelter has operated satisfactorily. The first blister copper was put on rail on March 21.

AUSTRALIA

Melbourne, Victoria, April 1

Asbestos Mine in Tasmania. A new company, Tasmanian Asbestos Mining Company, has been formed in this city with a capital of £60,000 to develop the extensive asbestos deposits occurring at Beaconsfield. The asbestos requirements of the Commonwealth are valued at £116,000, and all supplies at present are obtained from Canada. Beaconsfield asbestos is reported to equal in general quality that now imported.

New Bromo-Cyanide Plant. Erection of the bromo-cyanide treatment plant on the Boulder Perseverance Mine, Kalgoorlie, W.A., is expected to be complete by the beginning of June. This will be the only plant of its kind in Australia. The capacity is 250 tons per day, and the cost of treatment is not expected to exceed 10/-, a reduction of 6/- per ton.

Bulolo Gold Dredging, Ltd. Having bought the Bulowat and Burnside areas in the Mandated Territory of New Guinea from Placer Development, Ltd., Bulolo Gold Dredging, Ltd., has arranged to finance the installation of two dredges.

Sulphide Corporation to Reopen. Sulphide Corporation will resume operations at Broken Hill on April 4, after having been idle since December, 1930. About 550 will be given employment, and in engaging men, preference is being given to old employees. The ore of the Sulphide Corporation's Central mine assays 14.1 per cent zinc, 13.4 per cent lead, and 11.5 oz. silver, and the mill has a capacity, working 88 hours per week, of 12,000 tons per four weeks. This capacity could be substantially increased.

Australia Zinc Contract. Total purchases of Broken Hill Zinc concentrates by the British Government under the Zinc Contract totaled £13,057,000 up to March 31, 1931. The total loss to the government was £8,104,000, including £1,107,000 in 1930. The British auditor-general shows that whereas the average cost under the whole contract, f.o.b. Port Pirie, was 92/9 a ton, sales in 1930-31 averaged only 19/2 a ton. The average loss under the whole contract was 57/6 a ton of concentrates.

Gold Bounty for 1931. Australia's gold production in 1931 was approximately 592,000 oz. Output for the first half of the year was 258,359 oz., which exceeded 225,716 oz. (half the average output for 1928, 1929, and 1930) by 32,643 oz., and at £1 an ounce, gave a bounty of £32,643, or approximately 2/6 an ounce. Production for the second half of 1931 was about 333,641 oz., or an excess of 107,925 oz. over the figure at which the bounty begins. As the bounty for the period was 10/- an ounce, the total amount to be distributed in respect of the half year would be £53,962, or about 3/3 an ounce on the total production for the half year. Thus on these approximate and unofficial figures the Commonwealth's liability for the gold bounty in 1931 would be about £86,600.

Prospecting Activity in Victoria. The Victorian Department of Mines during 1931 equipped for prospecting the small army of 12,000 men, the total cost of this service being £78,000. In addition to supplying equipment the department paid 8/- per week to married men and 5/- per week to single. Most of the men assisted were at least able to find enough gold to buy necessities, and many did so well that they do not now need assistance.

Rose Shamrock and Thistle Gold Mine. At the company's half yearly meeting, G. Durham, chairman, stated that the Land Tax shoot of ore, which yielded 11,296 oz. of fine gold from 10,395 tons, was worked out, and it was proposed to deepen the shaft 300 ft., and carry out extensive exploration.

Mount Isa Smelter Return. In January, Mount Isa mill treated 39,416 tons of ore assaying 11.3 per cent lead, and 6.0 oz. silver. This tonnage yielded 8,153 tons of lead concentrates assaying 44.9 per cent lead and 22.8 oz. silver. When smelted, 3,704 tons of bullion was obtained. The milling gave a recovery of 82 per cent lead and 79 per cent silver. In February, 40,087 tons was crushed for a bullion yield of 3,458 tons assaying 99 per cent lead and 48.8 oz. silver. Adjustments will shortly be made to the mill to enable 2,000 tons daily to be treated.

Gold Production in Western Australia in February, 1932, was 44,672 oz., 6,302 oz. in excess of the output for the corresponding month last year, and the highest for February since 1920. For the first two months of 1932, 88,700 oz. have been produced, against 65,677 oz. for the first two months of 1931.

Boulder Perseverance's new bromo-cyanide plant construction is well up to schedule. All machinery purchased abroad has arrived on the mine with the exception of the Merrill Crowe precipitation unit. The bromo-cyanide process will be used exclusively. The plant will be capable of dealing with over 7,500 tons per month.

Great Boulder Proprietary ore reserves have increased about 50 per cent since last year. At the 1,950 level a connection has been made with the Ivanhoe mine on the east lode. Development is being accelerated on this level.

Broken Hill Proprietary has completed the agreement to take over an option on the Enterprise mine, which is situated in a central position on the Golden Mile, Kalgoorlie. The company is prospecting by diamond drilling and crosscutting from the 700 level of the North Kalgurli mine and from the 500 level of the Hamilton shaft on the Great Boulder mine. It is also continuing operations on Hannans North Extended at the north end of Kalgoorlie. The option on the Brilliant mine, at Coolgardie, has been terminated.

United Verde Extension's representatives arrived in Perth this week and will inspect the Mararoa leases at Reidy's, near Meckatharra. Representatives of Wiluna interests took a temporary option over the leases last year, but the option was never completed. Great Boulder also inspected the property last year, but though inspection confirmed the reports as to mineralization, the option was not finalized, as the company wanted interests nearer Kalgoorlie.

Arsenic, to the amount of 630 drums, averaging about 700 lb. per drum, was recovered in February from Leggo's arsenic plant on the Wiluna mines, and forwarded to Bendigo, Victoria, for refining. When the plant is in full working order from 75 to 80 tons of refined arsenic may be recovered per month.

At **Grants' Patch,** near Ora Banda, and north of Kalgoorlie, Messrs. Nicholson and Griffiths have opened up a promising gold-bearing lode. At Riche's lease, Carnage, in the same district, a parcel of 40 tons yielded about 60 oz. per ton. B. Franitovich has made a promising find at Brown Hill, some distance north of the old Brown Hill mine. The Messrs. Duckworth, of Menzies, secured 257 oz. of gold from a parcel of 41 tons. A few weeks previously they obtained 209 oz. from 38 tons.

At **North Kalgurli** mine, the latest report indicates that at the 122-ft. level on the Genevieve lease, the south drive has been extended from 402½ ft. to 413 ft. south of the Genevieve shaft. Average grade, 13 dwt. over 4 ft. On the 255-ft. level, the east crosscut off the north drive has been extended to 25 ft. The leading stope in the north drive of the 366-ft. level has been extended from 776 ft. to 782 ft., averaging grade 11 dwts. over 6 ft. 6 in. Timbering is proceeding satisfactorily on the 255-ft. level, No. 1 lode. The shaft is being reconditioned from surface to brace.

PHILIPPINE ISLANDS

Manila, P. I., March 30

Benguet Consolidated, whose properties are at Antamok, is enlarging its plant from a capacity of 330 tons per day to 500 to 600 tons, and will probably stabilize its operations on a basis of that tonnage when the plant has been stepped up to the enlarged capacity.

Baguio Gold has made arrangements to speed up its development work by the installation of the second Ingersoll-Rand compressor. Thirteen additional claims have been acquired and development is now being carried on in four tunnels.

SOUTH AMERICA

Diamantino, Brazil, April 6

A New Big Diamond. A prospector in the waste lands in the Matto Grosso (Great Jungle) district has found one of the largest diamonds in the world. The stone weighed 574 carats, and the prospector is said to have refused an offer of $80,000 by a broker at Rio de Janeiro. The diamond is the largest ever found in Brazil.

Catino Mines & Enterprises Consolidated decided, at the annual meeting held on April 12, to acquire the Sociedad Empressa de Estano de Araca by an exchange of stock, which will be one share of Patiño for one share of Araca, with warrants on Patiño shares that may result in the payment of up to one additional share of that stock, depending on the reserves uncovered on Araca property in the next ten years.

St. John del Rey Reserves. Ore reserves at the Morro Velho mine of St. John del Rey, in Minas Geraes, Brazil, are 1,522,271 tons averaging about 10 dwt. in gold per ton. This is a considerable increase over the total when the reserves were last estimated. The lowest levels, however, are not showing up very well and most of the increase came from four new small bodies opened in upper levels. Experiments in the mill have resulted in increasing stamp capacity by 7 per cent. Additional equipment is being obtained.

La Paz, Bolivia, April 4

The Tin Situation remains unchanged. More and more attention is being shown toward developing gold properties in this part of South America. With the end of the present rainy season, the lower Tipuani River will be drilled to determine its dredging possibilities. Across the line in Peru, the Woods concession on the Inambari watershed is soon to be extended for a further two years. In the same district, a series of morainal placer deposits on the Lake Titicaca watershed are being examined by American interests. A number of American miners and prospectors are awaiting the close of the rainy season to go into the region lying below Cuzco, on the Amazon drainage. Interesting gold developments may occur during 1932 in the district covering the upper Amazon drainage in northern Bolivia and southern Peru.

Lampa Mining Company, a British concern operating a silver-copper property at Santa Lucia, on the Southern Peruvian railway, near Puno, Peru, reports that a new plant will soon be erected. The orebody consists of a large manganese-iron replacement in limestone, carrying silver and copper. Some years ago, this ore was smelted along with purchased pyritic copper ores. With the decline in copper value, the ore was sorted to a high silver shipping product. Now it is planned to recover the manganese as a manganese sulphate shipping product. with the silver and copper in a separate product.

Production Statistics

The following figures covering metal production of important companies have been obtained from recently published annual reports. They refer to the fiscal years ended Dec. 31, 1930, and Dec. 31, 1931:

	1930	1931
Anaconda Copper (*a*)	**United States**	
Copper, short tons	98,617	86,720
Zinc, tons	113,278	62,992
Lead, tons	7,230	2,196
Gold, oz.	21,209	19,486
Silver, oz.	5,569,147	3,640,066
Cadmium, tons	494	141
Andes Copper		**Chile**
Copper, short tons	47,023	41,855
Gold, oz.	6,629	4,791
Silver, oz.	130,633	79,652
Braden Copper		**Chile**
Ore treated, short tons	3,943,775	5,612,726
Copper, tons	80,993	103,770
Chile Copper		**Chile**
Copper, short tons	89,596	85,814
Consolidated M. & S.		**Canada**
Ore, short tons	1,924,017	1,621,143
Copper, tons	7,064	608
Lead, tons	151,492	138,843
Zinc, tons	119,550	101,124
Cadmium, tons	228	162
Gold, oz.	25,782	24,968
Silver, oz.	6,936,759	6,572,119
Dome Mines		**Canada**
Ore treated, short tons	67,600	542,600
Gold bullion, value (*b*)	$775,266	$3,486,506
Giesche Spolka		**Poland**
Zinc, short tons	79,430	59,386
Lead, tons	9,624	10,295
Sulphuric acid, metric tons	68,381	44,947
Great Northern Iron Ore	**United States**	
Iron ore, long tons	7,092,312	3,182,041
Greene Cananea		**Mexico**
Copper, tons	21,212	20,936
Gold, oz.	7,941	8,447
Silver, oz.	279,729	278,231
Hudson Bay M. & S.		**Canada**
Ore, short tons	(*c*)	1,090,596
Copper, tons	(*c*)	15,534
Zinc, tons	(*c*)	17,528
Gold, oz.	(*c*)	73,000
Silver, oz.	(*c*)	702,128
Inspiration Cons.	**United States**	
Ore mined, short tons	3,041,854	2,625,331
Copper, tons	32,803	30,684
International Smelting	**United States**	
Copper, short tons	67,259	45,259
Lead, tons	53,930	26,095
Gold, oz.	77,877	42,955
Silver, oz.	6,155,916	2,955,120
Kennecott (*d*)	**United States**	
Ore mined, short tons	503,292	55,500
Copper, tons	11,495	6,785
Silver, oz.	204,941	126,091
Miami Copper	**United States**	
Ore, short tons	6,124,993	4,438,808
Copper, tons	38,562	25,286
Nevada Consolidated	**United States**	
Ore, short tons	7,727,388	6,177,949
Copper tons	79,901	65,478
Gold, oz.	29,165	26,670
Silver, oz.	123,746	107,191
North Lily	**United States**	
Ore shipped, short tons	55,717	23,699
Lead, tons	7,922	2,179
Zinc, tons	179	10
Gold, oz.	21,944	11,660
Silver, oz.	434,443	147,051
St. John del Rey		**Brazil**
Ore milled, long tons	202,500	221,800
Gold, oz.	123,161	115,473
Tybo Mines	**United States**	
Ore, treated, short tons	74,159	72,138
Lead concentrate, tons	5,877	6,232
Lead content, per cent	63	67
Zinc concentrate, tons	5,276	6,081
Zinc content, per cent	49	49
Utah Copper	**United States**	
Ore mined, short tons	9,552,500	8,147,764
Copper, tons	80,569	71,347
Gold, oz.	64,240	54,124
Silver, oz.	563,330	481,251
Walker Mining	**United States**	
Ore milled, short tons	518,509	432,294
Copper, tons	7,888	6,425
Gold, oz.	16,899	13,614
Silver, oz.	377,994	322,429
Wernecke Mines		**Yukon**
Ore treated, short tons	45,574	47,793
Concentrate, tons	4,169	4,109
Silver content, oz. per ton	778	795
Lead content, per cent	49	50
Ore shipped, tons	2,262	154
Silver content, oz. per ton	287	502
Lead content, per cent	42	70

(*a*) Butte mines only, plus custom ore received at Anaconda smelter. (*b*) Presumably in Canadian dollars. Report does not state. (*c*) Not available. (*d*) Alaska mines only.

Non-Ferrous Metal Prices Continue Heavy As World Trade Revival Lags

Though the movement of non-ferrous metals into consumptive channels was somewhat larger during April, contrasted with each of the other three preceding months of the year, the gain was so small as to bring about no improvement in sentiment. The industry had to contend with such unfavorable developments as a higher British tariff schedule, continued unsettlement in the European political situation, and uncertainty as to what Washington may finally do to balance the budget. In reference to prices, the tendency again was downward, with new all-time lows for copper and zinc. Antimony, tin, and silver made new lows for the movement. Our weighted index number of non-ferrous metal prices for April was 47.48, against 49.24 in March, and 64.45 in April, 1931. In April, 1930, the *E.&M.J.* index was 93.24. Production of major metals is still declining to offset the reduced rate of industrial activity.

Copper Dull

The curtailment in output to the basis of 20 per cent of capacity was put into effect promptly on April 1, in line with the plan agreed upon recently, and from present indications world stocks are no longer accumulating. However, the movement of copper into the really important consumptive channels has hardly changed, and except for a moderate increase in specifications from the automotive industry, business throughout the month was dull. Continued liquidation in financial markets had a depressing influence on commodities.

Agitation for a tariff on copper attracted wide attention, and strong efforts are being made to include a tax on the metal in the revenue bill. As the month of April came to a close the prospects for a tax were dimmed somewhat. On April 28, the Senate Finance Committee struck out all import taxes from the bill. Before the measure went to the Senate Committee, the House had approved of a 5c. import tax on copper. (Copper was again included on the tax bill May 4.) With huge stocks of copper in the hands of producers, and little in the way of improvement in demand, consumers failed to get excited over the tariff situation. Most consumers, it appears, would willingly pay more for copper if they could count on a sustained upturn in business.

According to the records of producers, foreign consumers should be running short of supplies, yet less copper was purchased for export during April than in any month since the beginning of the world depression. Sales for foreign account in April amounted to 8,660 long tons, against 19,880 long tons in March, and 25,960 long tons in February. Copper Exporters, Inc., maintained the so-called official price at 6¼c., c.i.f. European ports, but most of the metal sold during the month was disposed of on the "special" export basis of 6c.

The domestic price settled at 5¾c., delivered Connecticut, though actual business went through as low as 5⅝c., same terms, on April 29, a new all-time low. Inquiry for copper late in the month was almost absent.

Lead Steady

Sales of virgin lead for April delivery amounted to 26,850 tons, against 23,531 tons in the preceding month. All classes of consumers except the cable makers were well represented in the sales total for the month. The market ruled steady, the price holding at 3c., New York, the contract basis of the A. S. & R., and 2.90c., St. Louis. Further curtailment in output was announced during the period and producers feel that production and consumption will more than balance in the near future.

Total lead stocks at the works of smelters and refiners on April 1 were 238,743 tons, against 238,272 tons on March 1, according to the American Bureau of Metal Statistics. Prior to April 1, the statistics on total stocks showed a substantial increase for each month back to August, 1931.

Zinc at New Low

Selling pressure in zinc continued and prices registered a net loss of 25 points during the last month. Prime Western zinc sold during April down to 2.55c., St. Louis, a new all-time low. (On May 3, sales were noted at 2.50c.). Consumer demand was quiet throughout the period. Statistically, zinc appears to be in better condition than the other major metals, and the weakness in the market is said to be due to forced liquidation by two or three operators.

The European cartel is still functioning, despite the British tariff, and plans are under consideration for another reduction in output. Stocks abroad are being reduced.

Tin Unsettled

The price of Straits tin for prompt shipment, New York, declined to 18⅜c. per pound during the month on indications that the movement of the metal into consumptive channels has changed little since the first of the year. Toward the close, however, the market strengthened on reports to the effect that another drastic reduction in output has been agreed upon by the International Tin Committee. The plan of the cartel is to suspend production in the principal tin countries during June and July. Production is to be resumed in August at the rate of 40 per cent of present quotas. The world's visible supply at the end of April was estimated at 50,716 long tons, against 50,780 long tons a month previous.

Silver Lower

Weakness in China exchanges, and consequent sales of silver from that quarter, caused prices to fall below 28c. per ounce. Liquidation of speculative accounts also had a depressing influence on the market.

Zinc and Lead Concentrate

Owing to the weakness in the metal, the price of zinc concentrate closed the month at $16 per ton for Prime, basis 60 per cent zinc, a new all-time low for the Tri-State district.

Lead concentrate, basis 80 per cent lead, was quoted on April 30 at $22.50 to $27.50 per ton in the Joplin, Mo., market.

Complete Market News and Prices

THE monthly magazine you are now reading carries only a condensed review of important market news and price movements. For buyers and sellers of ores, metals, minerals, and scrap who require reliable information as soon as it is available, we now provide *Metal and Mineral Markets*, which goes to press at the close of the metal-market week each Wednesday. It is printed at high speed and is in the mails that evening. In compact form, ready for insertion in a ring binder, it is ideal for desk and reference use. It carries the standard *E.&M.J.* quotations used in contracts the world over, recognized as authoritative and dependable. *Metal and Mineral Markets* is priced to subscribers in the United States and its possessions at $3 per annum; to countries in the Americas but outside the United States, $6; elsewhere, $10 yearly: 52 issues. Address *M.& M.M.*, 330 West 42d St., New York City.

Other Metals

Quotations cover wholesale lots, f.o.b. New York, unless otherwise specified. London prices are according to latest mail advices, and at present are largely nominal in view of erratic sterling exchange.

ALUMINUM—Per lb., delivered, Alcoa commercial and mill ingot, 99 and 98 per cent, 23.30c.; Alcoa No. 12 alloy, 22c.; metallurgical ingot, 94 per cent plus, 23.30c.; 98@99 per cent, 22.90c. London, £95, less 2 per cent, per long ton, for 98 per cent ingots and bars.

ANTIMONY—Per lb., Chinese (duty paid) and American, spot 5.35c.; futures nominal at 5c.

BERYLLIUM—See Alloys.

BISMUTH—Per lb., in ton lots, 85c. London (dollar basis), 75c.

CADMIUM—Per lb., 55c. London, 2s 2d. Nominal.

CHROMIUM—Per lb., 97 per cent grade, spot, 88c.; contract 83c. per lb. contained chromium, maximum 1 or 2 per cent iron. (Usually sold as ferrochrome.)

COBALT—Per lb.: Metal imported from Belgium, 97@99 per cent, $2.50 less 35 per cent for cash. On yearly requirements, usual rebate of 5 to 10 per cent, as to quantity. London quotes $3.65 per kilo, subject to usual discounts.

INDIUM—Per oz., 98½ per cent, $90@$100 per oz. Nominal.

IRIDIUM—Per oz., $80@$90 for 98@99 per cent sponge and powder. London, £18@£20.

LITHIUM—Per lb., 98@99 per cent, 100-lb. lots, $15.

MAGNESIUM—Per lb., ingots (4x16 in.), 99.8 per cent, 30c. in carloads; 32c. in 100 lb. lots or more, l.c.l.; ⅜, ½, 1, and 2 lb. sticks, 5c. per lb. over ingot price; 1/10 and ¼ lb. sticks, 8c. per lb. extra.

MANGANESE—Per lb., 95@97 per cent, 42c. (Usually sold as ferromanganese.)

MOLYBDENUM—Per lb., in 10- to 50-lb. lots, C.P. powder, $9; 97 per cent, $4.50. (Usually sold as calcium molybdate or ferromolybdenum, which see.)

NICKEL—Per lb. electrolytic cathodes, 35c.; shot and ingot made from remelted electro, 36c. for single lots of spot metal. London, per long ton, £220 to £225, with prices nominal.

OSMIUM—Per oz., $65@$70. London, £15@£16.

PALLADIUM—Per oz., $19@$21. London, £4 10s, nominal.

PLATINUM—Per oz. Official price of leading interest, $40. Cash transactions between dealers and refiners several dollars less.

QUICKSILVER—Per flask of 76-lb., $67@$70. London, £17 5s.

RADIUM—Per mg. radium content, $50 in lots of 4 grams or more, to $65 for 1 gram; smaller quantities, $70.

RHODIUM—Per oz., $35@$50.

RUTHENIUM—Per oz., $38@$48.

SELENIUM—Per lb., $1.80@$2, depending on quantity, for black, powdered, 99.5 per cent pure.

SILICON—Per lb., minimum 97 per cent Si, maximum 1 per cent Fe, spot, 16c.; contract, 14c.

TANTALUM—Per kilo, $91 for C.P. bar or sheet.

TELLURIUM—Per lb., $2.

THALLIUM—Per lb., $12.50@$15.

TITANIUM—Per lb. in 50- to 100-lb. lots, 75 per cent, $5.

TUNGSTEN—Per lb., contained tungsten, 98 per cent, powdered, $1.45.

Metallic Ores

Prices in tons of 2,000 lb., or in "units" of 20 lb., unless otherwise stated.

ANTIMONY ORE—No sales reported. London, per long ton unit, 4s. for 60 to 65 per cent sulphide ore.

BERYLLIUM ORE—Per ton, minimum 10 per cent BeO, $20@$30, f.o.b. mines; minimum 12 per cent, $35.

CHROME ORE—Per long ton, c.i.f. Atlantic ports, Indian ores, $17.50 for 48@50 per cent Cr_2O_3 ore, and $19.50@$20 for 50@51 per cent ore. London, 80s. for 48 per cent Rhodesian.

COBALT ORE—Per lb. of Co, 12 to 14 per cent grade, 50c., f.o.b. cars, Ontario. Market nominal.

IRON ORE—Per long ton, Lower Lake ports. Lake Superior ores:

Mesabi, non-bessemer, 51½ per cent iron, $4.50. Old Range, non-bessemer, $4.65.

Mesabi, bessemer, 51½ per cent iron, $4.65. Old Range, bessemer, 51½ per cent, $4.80.

Eastern ores, cents per long ton unit, delivered at furnaces: Foundry and basic, 56 to 63 per cent, 10c.

Foreign ores, alongside docks Atlantic ports, cargo lots, cents per long ton unit:

North African and Swedish, low-phosphorus, 8@9c.

Spanish and North African, basic, 56@60 per cent, 7@8½c.

Swedish foundry or basic, 65@68 per cent, 8c.

Newfoundland foundry, 55 per cent iron, 8c. Nominal.

MANGANESE ORE—Per long ton unit of Mn, c.i.f. North Atlantic ports, cargo lots, exclusive of duty: Brazilian, 46@48 per cent Mn, 21c.; Chilean, 47 per cent minimum, 24, nominal; Indian, 48@50 per cent, 23c.; Caucasian, 52@55 per cent, 24c.; South African, 52@54 per cent, 23@24c.; 50 to 52 per cent, 22@23c.; 44 to 46 per cent, 21c.

Per ton in carload lots:

Chemical grades, powdered, coarse or fine, minimum 80 per cent MnO_2, Brazilian or Cuban, $50 in carloads, to $60 barreled. Javan or Caucasian, 85 per cent minimum, $50@$60. Domestic, 70 to 72 per cent, $43@$50 in carloads, f.o.b. mines.

MOLYBDENUM ORE—Per lb. of contained MoS_2, nominally 42c., delivered Pittsburgh, for 75@85 per cent concentrate; 30c., c.i.f. European ports. London, per long ton unit, nominal at 37s. to 38s. for 80@85 per cent concentrate.

Current Statistics of Production and Stocks of Copper, Lead, and Zinc

Data from American Bureau of Metal Statistics, American Zinc Institute, and Metallgesellschaft

All Figures Except Tin Represent Tons of 2,000 Lb.

	1931									1932		
COPPER — North and South America	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March
Production, refined, daily average	3,350	3,313	3,276	3,110	2,909	2,890	.....	.....	.....	.....	.....	.....
Domestic shipments	54,567	45,265	50,217	43,144	45,816	40,459	.....	.....	.....	.....	.....	.....
Foreign shipments	32,218	26,684	33,251	26,321	29,016	22,124	.....	.....	.....	.....	.....	.....
Stocks, blister and refined	561,797	589,345	600,827	620,075	631,880	658,321	.....	.....	.....	.....	.....	.....
LEAD — United States												
Production, refined, from domestic ore	35,498	39,519	30,708	32,157	34,144	31,966	36,546	31,671	33,576	32,180	28,081	30,345
Production, secondary and foreign	2,941	3,598	3,683	4,409	5,453	3,934	4,722	3,820	4,031	4,559	3,920	3,989
Production, total, daily rate	1,280	1,390	1,146	1,179	1,151	1,163	1,331	1,180	1,213	1,185	1,103	1,107
Shipments reported	35,324	34,081	37,054	42,219	38,590	38,059	34,276	31,216	30,297	27,867	26,319	31,162
Stocks, end of month	132,993	142,370	139,698	133,958	134,977	132,804	139,796	144,057	151,380	160,257	165,933	169,091
ZINC — United States												
Production, daily average	971	971	783	689	692	712	699	684	709	723	742	726
Domestic shipments	27,418	25,831	27,604	28,460	23,599	20,902	21,163	20,327	23,005	22,472	21,896	22,576
Export shipments	.....	20	.....	20	.....	.....	.....	.....	.....	31	.....	.....
Stocks, end of month	143,212	143,049	138,928	131,833	129,701	130,155	130,666	130,865	129,825	129,886	129,506	129,451
World Production Rate (Daily Average)												
Copper	4,296	4,209	4,224	3,919	3,924	4,023	.....	.....	.....	.....	.....	.....
Lead	4,898	3,988	3,995	3,691	3,906	3,654	3,806	3,980	3,958	3,906	3,838	3,838
Zinc	3,430	3,212	3,127	2,860	2,766	2,814	2,736	2,725	2,601	2,600	2,615	2,623
Tin (Metric Tons)	441	426	439	401	416	349	352	325	351	311	260	.....

TANTALUM ORE—Per lb., Ta_2O_5, $1.75 for 60 per cent concentrate.

TIN ORE — No market in United States. London quotes £9 to £9 10s. per ton returning charges on 60 per cent Bolivian ore.

TITANIUM ORE — Per gross ton, ilmenite, 45@52 per cent TiO_2, f.o.b. Atlantic seaboard, $10@$12, according to grade and impurities. Low-grade domestic, 32 to 35 per cent, about $7 @$8. Rutile, per lb., guaranteed minimum 94 per cent concentrate, 10c.

TUNGSTEN ORE—Per unit of WO_3, N. Y.; Chinese wolframite, $10.25@ $10.50, duty paid. Bolivian scheelite, $10.50. Domestic, $10@$10.50.

VANADIUM ORE—Per lb. V_2O_5 contained, 26c., f.o.b. shipping point.

ZIRCON ORE—Per ton, 55 per cent ZrO_2, f.o.b. Atlantic seaboard, $40@$45 in 30-ton lots. Crude granular zircon, $70, f.o.b. Suspension Bridge, N. Y.; milled, $90.

Non-Metallic Mineral

Prices received for non-metallic minerals vary widely and depend upon the physical and chemical characteristics of the commodity. Hence the following quotations can serve only as a general guide to the prices obtained by producers and dealers in different parts of the United States for their own product. In the last analysis the value of a particular non-metallic mineral can be ascertained only by direct negotiation between buyer and seller.
Tons of 2,000 lb. unless otherwise noted.

AMBLYGONITE — Per ton, f.o.b. mines, 8@9 per cent Li_2O, $50@$60.

ASBESTOS — Per ton, f.o.b. Quebec mines, tax and bags included: Crude No. 1, $400 (nominal); crude No. 2, $200; spinning fibers, $75@$125; Magnesia and compressed sheet fibers, $70@$85; various grades shingle stock, $45@$60; various grades paper stock, $27.50@$35; cement stock, $15@$20; floats, $10@$15.

Per ton c.i.f. New York: Rhodesian crude No. 1, $170; No. 2, $120. Nominal.

Per ton, c.i.f. New York: Russian crude No. 1, $200@$225; No. 2, $150@ $175; No. 3, $125. Nominal.

Per ton, f.o.b. mines, Vermont: Shingle stock, $40@$45; paper stock, $30@$35; cement stock, $18@$22.

BARIUM CARBONATE (Witherite) — Per ton, 90 per cent 300 mesh, $42; 100 mesh, $39.

BARYTES—F.o.b. mines:

California: Crude, $7 per ton.

Georgia: Barytes ore, crude, $6@ $6.50 per long ton.

Missouri: Per ton, water ground and floated, bleached, $23, car lots, f.o.b. works. Crude ore, minimum 95 per cent $BaSO_4$, less than 1 per cent iron, $6; 1 per cent iron and 93 per cent $BaSO_4$, $5.50; low-grade, $4.50, f.o.b. mines.

BAUXITE—Per long ton: Domestic ore, chemical, crushed and dried, 55 to 58 per cent Al_2O_3, 1.5 to 2.5 per cent Fe_2O_3, $6.50@$8, f.o.b. *Alabama* and *Arkansas* mines. Other grades, 56 to 59 per cent Al_2O_3, 5 to 8 per cent SiO_2, $6@$7.50, f.o.b. *Arkansas* mines. Pulverized and dried, 56 to 59 per cent Al_2O_3, 8 to 12 per cent SiO_2, $10@ $12.25, f.o.b. *Arkansas* mines; abrasive grade, crushed and calcined, 78 to 84 per cent Al_2O_3, $14@$16, f.o.b. *Arkansas* mines.

Per metric ton, foreign, c.i.f. Atlantic ports: Dalmatian, 50 to 55 per cent Al_2O_3, 1 to 3 per cent SiO_2, $4.50@ $6. Istrian, 54 to 57 per cent Al_2O_3, 3 to 5 per cent SiO_2, $5.50@$6.50; French, 56 to 59 per cent Al_2O_3, 2 to 4 per cent SiO_2, $5.50@$7.

BENTONITE—Per ton, carload lots, f.o.b. *Wyoming* mines, dried and crushed, in bulk, $8; in bags, $10. F.o.b. Chicago, selected air-floated, $25.

BORAX—Per ton, granular, contract, $36; carload lots, $40, delivered.

CELESTITE—Per ton in carload lots, 90 per cent $SrSO_4$, finely powdered, $27.

CHINA CLAY (Kaolin)—Per ton, f.o.b. *South Carolina* mines, crude lump, No. 1, $4@$5; crushed, $6.90; pulverized, $9@$15.

Florida, washed and crushed, No. 1, $12.50; No. 2, $12.

Delaware, No. 1, $14.50.

Imported English, f.o.b. American ports: lump, $17@$21 in bulk.

DIATOMITE—Per ton, f.o.b. *Nevada,* crude, dried, in bags, $10; minus 40 mesh, $15; 300 mesh, $20; high temperature insulation, $30.

EMERY—Per ton, f.o.b. *New York,* domestic crude ore, first grade, $10. Other American ore, delivered to grinders, per gross ton, $16; Turkish and Naxos ore, $30@$35. F.o.b. *Pennsylvania,* in 350-lb. kegs, Turkish, Khasia, and Naxos grain emery, 6½c. per lb.; American, 3½c.

FELDSPAR — Per ton, f.o.b. *North Carolina,* potash feldspar, 200 mesh, white, $15, in bulk; soda feldspar, $18. F.o.b. *Maine,* potash feldspar, white, 200 mesh, $19, in bulk. Granular glass-spar, white, 20 mesh, f.o.b. *North Carolina,* $10.50 in bulk.

Virginia, No. 1, 325 mesh, $17; 200 mesh, $15@$16; 160 mesh, $14@$15; No. 1 glassmakers', $9.50, Spruce Pine basis; enamelers', $12.50@$14.50.

New Mexico: Crude clean No. 1 potash spar, $4.75; ground, $9.50.

FLUORSPAR—Per net ton, 85 per cent CaF_2, and not over 5 per cent SiO_2, *Kentucky* and *Illinois* mines, contract, freight allowed Pittsburgh basis: Washed gravel, $20.31; No. 2 lump, $22.31.

Ground fluorspar, f.o.b. *Illinois* mines, 95 to 98 per cent CaF_2 and not over 2½ per cent SiO_2, $30 in bulk; $34 in bags or barrels.

F.o.b. *Colorado* mines, 82-5, $10.

Foreign fluorspar, gravel, 85-5, $19.50 @$20 per gross ton, duty paid, Baltimore or Philadelphia.

FULLER'S EARTH — Per ton, f.o.b. *Colorado,* $18, various finenesses to minus 90 mesh.

F.o.b. *Georgia* or *Florida,* 30 to 60 mesh, $15; 15 to 30, $14.50; 200 up, $10; 100 up, $7.

GARNET—Per ton, f.o.b. *New Hampshire* mines; concentrate, $40; washed grades, $125.

New York: Adirondack garnet concentrates, $85.

Spanish grades, $60, c.i.f. port of entry.

GILSONITE — Per ton, carload lots, f.o.b. *Colorado.*

Brilliant black, $32.90; seconds (mine run), $25.50.

Selects, $30.50, f.o.b. Utah. Nominal.

GRAPHITE—Per lb., f.o.b. *New York:* Ceylon lump, 6½@7½c.; carbon lump, 3@6c.; chip, 5@6c.; dust, 3@4c.; Madagascar flake, 5@6c.

No. 1 flake, 8@16c.; No. 2, 5½c. upward; fine ground, 55 to 70 per cent carbon, 3c. upward; amorphous, 3c. upward.

Crude amorphous graphite, $12@$23 per ton, according to grade.

GREENSAND — Per ton, f.o.b. cars, *New Jersey:* Screened and bagged, best grade, in carload lots, $20.

GYPSUM—Per ton, f.o.b. mill, crushed rock, *Iowa,* $2.50; *Ohio* and *New York,* $3. Ground, *Ohio,* $4; *Iowa,* $6. Agricultural, $6@$7. Calcined, $6@$9.

IRON OXIDE (See Ocher)—Per lb.: Standard Spanish red, 3@4½c.; domestic earth, 2@4½c.

KAOLIN—See China Clay.

KIESELGUHR—See Diatomite.

LEPIDOLITE—Per ton, $50@$60 for ordinary grades. Nominal.

LIMESTONE—Per ton, f.o.b. shipping points, depending on location, either lump or crushed, 25c.@$1.75.

Agricultural, $1 up to $6 per ton, as to grade and point of shipment.

MAGNESITE—Per ton, f.o.b. *California,* dead-burned, $25. Kiln run, 93 per cent MgO (artificial periclase), $68; 88 per cent MgO, $35. Caustic, 95 per cent MgO, $45; 90 per cent, $40. *Washington:* Dead-burned grain magnesite, $22.

MICA—Per ton, f.o.b. *New Mexico,* scrap, white, $21; off color, $18. Punch, white, for disks, per lb., 10c.; for washers, 8c.

Per ton, f.o.b. *New Hampshire,* roofing mica, $23; snow, $34; 40 mesh white, $40; 60 mesh, $48; 100 mesh, 60; 200 mesh, $75. Clean dry mixed bench and mine scrap, $13.

Per lb., f.o.b. *North Carolina:* Punch, 3@5c.; 1½x2 in., 20@30c.; 2x2, 30@50c.; 2x3, 60@90c.; 3x3, $1 @$1.40; 3x4, $1.40@$1.80; 3x5, $1.50 @$2; 4x6, $2.25@$3; 6x8, $2.50@ $3.75; 8x10, $5@$7.50. These prices apply both to No. 1 and No. 2 mica. Black-stained mica takes a discount of 10 to 25 per cent from this schedule. White North Carolina mica, 70 mesh, $60 to $80. Biotite, or black mica, $15 a ton, unground. White, Georgia, 300

mesh, $19.50; sericite, 300 mesh, $15 per ton.

MINERAL BLACK—(Graphitic shale)—Per ton, 325 mesh, 75 per cent carbon, $22.50, f.o.b. *Virginia.*

MONAZITE—Per ton, minimum 6 per cent ThO_2, $60.

OCHER—Per ton, f.o.b. *Georgia* mines, $17.50 in sacks; $21 in barrels. Buff clay, 98 per cent through 325 mesh, $18.

F.o.b. *Virginia,* dark yellow, 300 mesh, 60 per cent ferric oxide, in jute bags, $19.50.

PHOSPHATE—Per long ton, f.a.s. or f.o.b. mines:

Florida, pebble, f.a.s., for export: 76@77 per cent, $7.15; 75 per cent, $6.40; 74@75 per cent, $6.15; 70 per cent, $4.65; 68 per cent, $4.10.

Florida, pebble, domestic: 76@77 per cent, $6.50; 74@75 per cent, $5.50; 72 per cent, $4.50; 70 per cent, $4.

Tennessee, ground lime phosphate, 80 per cent through 300 mesh, 33 per cent P_2O_5, $12.80 per net ton, bags extra. Rock phosphate, 29 per cent P_2O_5, 200 mesh, $9.50. Furnace lump, $6.25.

POTASH—Per ton, contracts:

	Bags	Bulk
Muriate of potash, 80@85 per cent, basis 80 per cent	$37.15	$35.55
Sulphate of potash, 90@95 per cent, basis 90 per cent	48.25	46.65
Sulphate of potash-magnesia, 48@53 per cent, basis 48 per cent	27.80	26.20
Manure salt, 30 per cent	22.15	19.15
Manure salt, 20 per cent	15.65	12.65
Kainit, 14 per cent	12.70	9.70

Prices are delivered to Atlantic ports. Discounts up to 4 per cent for early shipment. Spot prices, $1.25@$1.50 per ton higher than on contract.

PUMICE STONE—Per lb., f.o.b. New York or Chicago, in barrels, powdered, 2½@4c.; lump, 5@7c.

PYRITES—Per long ton unit of sulphur, c.i.f. United States ports, guaranteed 48 per cent sulphur, Spanish, 12c., nominal.

QUARTZ ROCK CRYSTALS—For fusing, all sizes, $250 per ton. Prisms for piezo-electrical and optical use command premium.

SILICA—Per ton, water ground and floated, in bags, f.o.b. *Illinois:* 325 mesh, $16@$40 for 92 to 99½ per cent grades. Dry ground, air-floated, 325 mesh, 92@99½ per cent silica, $14@$30. Glass sand f.o.b. producing plant, $1.25@$5 per ton; molding sand, 50c.@$3.50; blast sand, $1.75@$6. *California:* $5 for quartz and $2.50 for sand.

STRONTIANITE—Per ton, lump in carload lots, minimum 90@92 per cent $SrCO_3$, $100.

SULPHUR—Per long ton for domestic market, $18 f.o.b. Texas mines.

TALC—Per ton, carload lots, f.o.b. works, containers included unless otherwise specified:

New Jersey: Soapstone, ground, $10@$12.

New York: Double air floated, short fiber, 200 mesh, $13.75; 325 mesh, $14.75.

Vermont: 99 per cent through 200 mesh, extra white, bulk basis, $7.50@$8; 97 to 98 per cent through 200 mesh, medium white, $6.50@$7. Packing in paper bags, $1 per ton extra.

Virginia: 200 mesh, $4.60@$5.50, 325 mesh, $8@$9.25.

TRIPOLI — Per ton, burlap bags, paper liners, minimum carload 30 tons, f.o.b. *Missouri:* Once ground through 40 mesh, rose and cream colored, $15. Double ground through 110 mesh, rose and cream, $17. Air-floated through 200 mesh, rose and cream, $25.

WHITING—Per ton, f.o.b. *Georgia,* white, 300 mesh, $7.

Metallic Compounds

ARSENIOUS OXIDE (White arsenic)—Per lb., 4c., delivered, all positions.

CALCIUM MOLYBDATE OR MOLYTE—Per lb. of contained Mo, 85c.

COBALT OXIDE—Per lb., black oxide, 70@71 per cent grade, $1.35.

COPPER SULPHATE (Blue Vitriol)—Per lb., in car lots, 2.75c. for either large or small crystals.

SODIUM NITRATE—Per 100 lb., crude natural, in bags ex vessel, Atlantic ports, $1.77.

SODIUM SULPHATE (Salt Cake)—Per ton, bulk, f.o.b. works, $16@$18.

ZINC OXIDE—Per lb. in bags, in car lots: Lead-free, 5¾c.; 10, 20 or 35 per cent leaded grades, 5¼c.; French red seal, in bags, 8⅝c.

ZIRCONIUM DIOXIDE—Per lb., carload lots, commercial, 38@43c.

Refractories

CHROME BRICK—Per ton, f.o.b. shipping point, $42.50. Grecian refractory ore, $15 per net ton, f.o.b. Chester, Pa.

FIRECLAY BRICK—Per M., first quality, $38, *Ohio, Kentucky, Central Pennsylvania;* second quality, $30; first quality, *Missouri,* $35.

MAGNESITE—Brick, per ton, f.o.b. works, 9-in. straights, $61.50. Dead-burned grain, $38.50, f.o.b. Chester, Pa., or Baltimore.

SILICA BRICK—Per M., *Pennsylvania,* $38; *Alabama,* $50; *Illinois* and *Indiana,* $47.

ZIRKITE—Per lb., powdered, 65@70 per cent ZrO_2, 3½c. Brick, straights, 80c.@$1 each.

Rolled Metals

COPPER—Per lb., sheets, hot-rolled, 15⅜c.; wire, f.o.b. mill, 8c.

LEAD SHEETS—Per lb., full rolled, 6¼c.; clipped, 6½c.

MONEL METAL—Per lb., sheets, full finished, 42c.; strip, cold-rolled, 45c.; rods, hot-rolled, 35c.

MUNTZ METAL—Per lb., rods, 11¼c.; sheets, 14⅜c.

NICKEL—Per lb., sheets, full finished, 52c.; rods, hot-rolled, 45c.

NICKEL SILVER—Per lb., sheets, 10 per cent, 20⅜@21c.; 18 per cent, 24⅛@24½c. Wire and rods, 10 per cent, 24½c.; 15 per cent, 28½c.; 18 per cent, 31⅜c.

PHOSPHOR BRONZE—Per lb., sheets and rods, 5 per cent tin, 26½c.; wire, 5 per cent, 26⅜c.; 10 per cent, 31½c.

ZINC SHEETS—Per lb., 9c., f.o.b. works; ribbon, 8½c.; 7 per cent discount on orders for 18 tons or more.

Alloys

BERYLLIUM-COPPER—Per lb., containing 12.5 per cent of Be, $6.35.

FERROCHROME—Per lb. of contained chromium, 4 to 6 per cent carbon, 66 to 70 per cent chromium, 10c., delivered, on contract; spot, ton lots, 10½c. Containing 2 per cent carbon, 67 to 72 per cent chromium, 17c.; maximum 0.10 per cent carbon, 23½c.

FERROMANGANESE—Per gross ton, furnace: domestic and foreign, 78@82 per cent, $72@$75, contracts, depending on quantity. Spiegeleisen, 19@21 per cent, $27 for spot carloads.

FERROMOLYBDENUM—Per lb. of Mo, f.o.b. shipping point, 50@60 per cent Mo, 95c.

FERROPHOSPHORUS—Per gross ton, 18 per cent P, $91; electrolytic, 24 per cent, $122.50, f.o.b. *Alabama* and *Tennessee.*

FERROSILICON—Per gross ton, delivered, 50 per cent, $77.50; 75 per cent, $126; 14@16 per cent, $31, f.o.b. Niagara Falls, N. Y. Spot shipments $5@$10 per ton higher on 50 and 75 per cent grades.

FERROCARBONTITANIUM — Per ton, $140, f.o.b. producer's plant, carlots.

FERROTUNGSTEN—Per lb. of W contained, 75@80 per cent W, $1@$1.10, f.o.b. works.

FERROVANADIUM—Per lb. of V contained, delivered, $3.05@$3.30.

SILICOMANGANESE — Per long ton, carload contracts, delivered, $105 for maximum 2½ per cent carbon; $115 for maximum 1 per cent carbon.

SILICON ZIRCONIUM—Per lb., 47@52 per cent Si, 35@40 per cent Zr, 16@19c.

ZIRCONIUM FERROSILICON—Per gross ton, 12@15 per cent Zr, 39@43 per cent Si, $97.50@$105.

Iron, Steel, and Coke

IRON—Per gross ton, Valley furnaces: Bessemer, $15; basic, $14.50; and No. 2 foundry, $15.

STEEL—Per gross ton, base prices, Pittsburgh, billets and slabs, $27; bars, plates, and structural shapes, per 100 lb., $1.50.

COKE—Per ton, Connellsville furnace, $2.25@$2.35. Connellsville foundry, $3.25@$4.25. Birmingham furnace, $3.50@$4.50. Byproduct coke, Ohio and Kentucky (Connellsville basis), $5.50; Buffalo and Detroit, $8@$8.50; Birmingham foundry, $5.

Daily and Average Monthly Prices of Metals

April, 1932

United States Market

April	Electrolytic Copper, Refinery	Straits Tin New York	Lead New York	Lead St. Louis	Zinc St. Louis
1	5.775	20.125	3.00	2.90	2.75@2.80
2	5.775	19.950	3.00	2.90	2.80
4	5.775	19.375@19.60	3.00	2.90	2.80
5	5.775	19.375@19.60	3.00	2.90	2.80
6	5.525@5.650	19.125@19.30	3.00	2.90	2.80
7	5.525	19.125	3.00	2.90	2.80
8	5.525	18.750	3.00	2.90	2.75@2.80
9	5.525	18.725	3.00	2.90	2.80
11	5.525	18.500	3.00	2.90	2.80
12	5.525	18.375@18.45	3.00	2.90	2.80
13	5.525	18.400	3.00	2.90	2.75@2.80
14	5.525	18.35 @18.50	3.00	2.90	2.75
15	5.525	18.600	3.00	2.90	2.75@2.775
16	5.525	18.550	3.00	2.90	2.775
18	5.565	18.950	3.00	2.90	2.775
19	5.525	19.000	3.00	2.90	2.75
20	5.525	19.375	3.00	2.90	2.75
21	5.525	20.250	3.00	2.90	2.70@2.75
22	5.525	19.65@20.00	3.00	2.90	2.65@2.75
23	5.525	20.25@20.50	3.00	2.90	2.60@2.65
25	5.525	20.000	3.00	2.90	2.60
26	5.525	19.750	3.00	2.90	2.60
27	5.525	19.450	3.00	2.90	2.60
28	5.525	19.500	3.00	2.90	2.60
29	5.40@5.525	19.125	3.00	2.90	2.55@2.60
30	5.325	19.000	3.00	2.90	2.55
Av. for month	5.565	19.244	3.000	2.900	2.725
Averages for Week					
April					
6	5.744	19.835	3.000	2.900	2.796
13	5.525	18.652	3.000	2.900	2.792
20	5.532	18.817	3.000	2.900	2.760
27	5.525	19.942	3.000	2.900	2.642
Calendar Week Averages					
April					
2	5.775	20.854	3.000	2.900	2.794
9	5.619	19.131	3.000	2.900	2.796
16	5.525	18.481	3.000	2.900	2.777
23	5.532	19.629	3.000	2.900	2.721
30	5.515	19.471	3.000	2.900	2.588

Silver, Gold, and Sterling Exchange New York and London

April	Sterling Exchange "Checks"	Sterling Exchange "90-Day" Demand	Silver New York	Silver London	Gold, London
1	379.000	381.0000	29.625	17.4375	108s 4d
2	375.750	378.0000	29.500	17.5000	.....
4	378.000	380.0000	29.125	17.3750	109s 11d
5	376.750	378.6250	29.000	17.2500	109s 5d
6	379.000	380.7500	28.750	17.0000	109s 8d
7	377.500	379.5000	28.375	16.8125	109s ..d
8	378.000	380.5000	28.375	16.8125	109s 8d
9	379.250	381.5000	28.250	16.6875	.....
11	379.500	381.7500	28.500	16.9375	109s 4d
12	379.625	381.6250	28.250	16.8125	109s 2d
13	377.875	379.3750	28.000	16.6250	109s 5d
14	376.875	378.3750	27.875	16.5000	109s 7d
15	377.000	377.8750	28.250	16.6875	109s 9d
16	376.875	377.8750	28.500	17.0000	.....
18	378.250	379.1250	28.250	16.6875	109s 9d
19	378.250	379.3125	28.125	16.5625	109s 3d
20	376.500	377.5000	28.125	16.7500	110s ..d
21	376.000	376.625	28.375	16.8125	109s 11d
22	374.250	374.500	28.375	17.0000	110s 6d
23	374.125	374.375	28.000	16.8750	.....
25	369.625	370.000	28.000	17.0000	110s 10d
26	363.500	363.750	28.000	17.0000	113s 3d
27	365.500	366.000	27.875	17.1875	113s 5d
28	365.500	366.000	27.500	16.8750	112s 8d
29	365.000	365.750	27.375	16.9375	113s 4d
30	365.500	366.000	27.375	16.8750	.....
Av. for month	374.731	.....	28.298	16.923	.....
Averages for Week					
April					
6	377.667	.....	29.292	.....	.....
13	378.625	.....	28.292	.....	.....
20	377.292	.....	28.188	.....	.....
27	370.500	.....	28.104	.....	.....

Calendar week averages: New York Silver, April 2nd; 29.708c.; 9th., 28.646c.; 16th., 28.229 c.; 23rd, 28.208c.; 30th, 27.688c.

London Market

April	Copper Standard Spot	Copper Standard 3 Mo.	Copper Electrolytic (Bid)	Tin Spot	Tin 3 Mo.	Lead Spot	Lead 3 Mo.	Zinc Spot	Zinc 3 Mo.
1	29.7500	30.0000	33.00	106.625	108.250	9.8750	10.1250	10.7500	11.1875
4	30.3750	30.5625	33.00	111.125	113.000	11.1250	11.3750	11.1250	11.5625
5	30.5000	30.4375	34.00	109.000	111.000	11.0625	11.3750	10.8750	11.2500
6	30.1250	30.0000	34.25	108.500	110.625	10.8125	11.1250	10.5625	10.9375
7	29.5000	29.5000	34.00	106.750	109.250	10.8750	11.1875	10.5625	11.0000
8	29.1875	29.3750	34.00	105.125	107.625	10.9375	11.1875	10.8125	11.2500
11	29.4375	29.6875	34.00	104.375	106.625	11.0000	11.2500	10.8750	11.3125
12	29.2500	29.5000	34.00	102.250	104.500	11.0000	11.2500	11.0000	11.3750
13	29.3750	29.6250	34.00	103.375	105.500	11.0000	11.2500	11.1250	11.5000
14	29.4375	29.7500	34.00	103.750	106.000	11.3125	11.5625	11.4375	11.7500
15	30.3750	30.6875	34.75	105.000	107.000	11.4375	11.6875	11.8750	12.1250
18	30.5625	30.8750	35.00	106.000	108.000	11.5625	11.8125	12.3125	12.5625
19	29.7500	30.1250	34.00	106.375	108.625	11.3125	11.6250	12.2500	12.3125
20	29.5625	30.0000	34.00	108.375	110.375	11.3125	11.6250	12.3750	12.3750
21	30.2500	30.6250	34.50	115.000	117.250	11.5000	11.8750	12.4375	12.6250
22	30.0000	30.3750	34.50	112.000	114.000	11.8750	12.1875	12.8750	13.1250
25	30.5625	30.8750	34.50	117.250	119.500	11.8125	12.0625	12.5625	12.7500
26	30.4375	30.6250	35.00	116.250	118.250	11.7500	12.0000	12.5625	12.8125
27	30.2500	30.3750	34.50	114.500	116.625	11.6250	11.8750	12.5000	12.7500
28	30.0625	30.1875	34.50	113.750	115.875	11.2500	11.5000	12.1250	12.2500
29	30.0625	30.0000	34.50	112.250	114.750	11.2500	11.6250	12.0625	12.3125
Average for month	29.943	.....	34.190	108.935	.....	11.223	11.503	11.670	11.958

The United States quotations are our appraisal of the major markets for domestic consumption based on sales reported by producers and agencies. They are reduced to the basis of cash, New York or St. Louis, as noted. All prices of domestic class are in cents per pound.

Copper, lead and zinc quotations are based on sales for both prompt and future deliveries; tin quotations are for prompt delivery only.

Quotations for zinc are for ordinary Prime Western brands. Zinc in New York is now quoted at 0.35c. per pound above St. Louis, this being the freight differential. Contract prices for High-Grade zinc delivered in the East and Middle West are 1c. above St. Louis

Silver and Sterling Exchange

	New York		London Spot		Sterling Exchange	
	1931	1932	1931	1932	1931	1932
January	29.423	29.780	13.810	19.623	485.260	342.515
February	26.773	30.136	12.432	19.573	485.551	345.141
March	29.192	29.810	13.524	18.336	485.596	363.463
April	28.279	28.298	13.120	16.923	485.764	374.731
May	27.650	.....	12.858	.....	486.188	.....
June	27.250	.....	12.707	.....	486.291	.....
July	28.255	.....	13.197	.....	485.349	.....
August	27.524	.....	12.815	.....	485.284	.....
September	28.180	.....	14.101	.....	451.245	.....
October	29.538	.....	17.153	.....	388.029	.....
November	32.223	.....	19.393	.....	371.130	.....
December	30.120	.....	20.023	.....	336.798	.....
Year	28.700	.....	14.594	.....	452.707	.....

New York quotations, cents per ounce troy, 999 fine. London, pence per ounce, sterling silver, 925 fine. Sterling exchange in cents.

Copper

	F.O.B. Refinery		London Spot			
	Electrolytic		Standard		Electrolytic	
	1931	1932	1931	1932	1931	1932
January	9.838	7.060	44.938	39.459	47.524	46.200
February	9.724	5.965	45.372	36.917	47.950	41.381
March	9.854	5.763	44.818	33.039	47.699	36.786
April	9.392	5.565	42.694	29.943	45.375	34.190
May	8.665	.....	38.897	.....	42.175	.....
June	8.025	.....	35.827	.....	38.966	.....
July	7.698	.....	34.402	.....	37.293	.....
August	7.292	.....	32.572	.....	35.388	.....
September	6.988	.....	31.503	.....	36.148	.....
October	6.775	.....	34.957	.....	41.000	.....
November	6.558	.....	35.854	.....	41.190	.....
December	6.580	.....	38.273	.....	44.409	.....
Year	8.116	.....	38.342	.....	42.093	.....

New York quotations, cents per pound. London, pounds sterling per long ton.

Lead

	New York		St. Louis		London			
	1931	1932	1931	1932	1931 Spot	1931 3 Mos.	1932 Spot	1932 3 Mos.
January	4.802	3.750	4.604	3.550	13.872	13.905	15.084	15.128
February	4.552	3.712	4.340	3.499	13.444	13.550	14.560	14.571
March	4.527	3.150	4.276	2.993	13.128	13.355	12.345	12.634
April	4.412	3.000	4.164	2.900	12.375	12.606	11.223	11.503
May	3.818	.....	3.651	.....	11.491	11.778	.....	.....
June	3.917	.....	3.761	.....	11.582	11.952	.....	.....
July	4.400	.....	4.225	.....	12.731	12.899	.....	.....
August	4.400	.....	4.225	.....	11.944	11.994	.....	.....
September	4.400	.....	4.217	.....	11.932	12.026	.....	.....
October	3.964	.....	3.773	.....	13.227	13.270	.....	.....
November	3.937	.....	3.758	.....	14.577	14.491	.....	.....
December	3.792	.....	3.592	.....	15.188	15.361	.....	.....
Year	4.243	.....	4.049	.....	12.958	13.099	.....	.....

New York and St. Louis quotations, cents per pound. London, pounds sterling per long ton.

Tin

	New York		London	
	1931	1932	1931	1932
	Straits		Spot	
January	26.137	21.804	115.798	140.219
February	26.315	22.018	117.919	139.143
March	27.065	21.863	121.852	129.810
April	25.222	19.244	112.775	108.935
May	23.221	.....	104.331	.....
June	23.478	.....	104.966	.....
July	24.978	.....	111.478	.....
August	25.738	.....	114.875	.....
September	24.618	.....	117.813	.....
October	22.723	.....	126.932	.....
November	22.779	.....	132.857	.....
December	21.328	.....	138.909	.....
Year	24.467	.....	118.375	.....

New York quotations, cents per pound. London, pounds sterling per long ton.

Zinc

	St. Louis		London			
	1931	1932	1931 Spot	1931 3 Mos.	1932 Spot	1932 3 Mos
January	4.035	3.011	12.747	13.113	14.416	14.834
February	4.012	2.817	12.303	12.694	13.872	14.289
March	4.002	2.787	12.190	12.676	12.616	13.024
April	3.717	2.725	11.353	11.838	11.670	11.958
May	3.306	.....	10.484	10.875	.....	.....
June	3.416	.....	11.270	11.750	.....	.....
July	3.893	.....	12.280	12.802	.....	.....
August	3.817	.....	11.444	12.028	.....	.....
September	3.744	.....	11.571	12.063	.....	.....
October	3.377	.....	12.733	13.216	.....	.....
November	3.209	.....	13.845	14.247	.....	.....
December	3.149	.....	14.361	14.818	.....	.....
Year	3.640	.....	12.215	12.677	.....	.....

St. Louis quotations, cents per pound. London, pounds sterling per long ton.

Cadmium and Aluminum

	Cadmium		Aluminum	
	1931	1932	1931	1932
January	67.115	55.000	23.300	23.300
February	55.000	55.000	23.300	23.300
March	55.000	55.000	23.300	23.300
April	55.000	55.000	23.300	23.300
May	55.000	.....	23.300	.....
June	55.000	.....	23.300	.....
July	55.000	.....	23.300	.....
August	55.000	.....	23.300	.....
September	55.000	.....	23.300	.....
October	55.000	.....	23.300	.....
November	55.000	.....	23.300	.....
December	55.000	.....	23.300	.....
Year	56.010	.....	23.300	.....

Aluminum in cents per pound, 99 per cent grade.
Cadmium, cents per pound.

Antimony, Quicksilver, and Platinum

	Antimony (a) New York		Quicksilver (b) New York		Platinum (c) New York	
	1931	1932	1931	1932	1931	1932
January	7.317	5.976	103.000	64.900	36.000	40.000
February	7.069	6.489	100.205	66.304	34.000	40.000
March	7.127	6.188	100.423	72.537	29.538	40.000
April	6.888	5.746	102.077	72.125	26.346	40.000
May	6.524	.....	101.140	.....	24.980	.....
June	6.342	.....	92.058	.....	37.115	.....
July	6.802	.....	85.808	.....	40.000	.....
August	6.596	.....	80.115	.....	40.000	.....
September	6.542	.....	76.300	.....	40.000	.....
October	6.517	.....	72.385	.....	40.000	.....
November	6.679	.....	68.587	.....	40.000	.....
December	6.231	.....	66.115	.....	40.000	.....
Year	6.720	.....	87.351	.....	35.665	.....

(a) Antimony quotations in cents per pound, for ordinary brands. (b) Quicksilver in dollars per flask of 76 lb. (c) Platinum in dollars per ounce troy.

Pig Iron[1]

	Bessemer		Basic		No. 2 Foundry	
	1931	1932	1931	1932	1931	1932
January	17.50	16.00	17.00	15.00	17.00	15.50
February	17.29	15.68	16.79	14.68	16.79	15.18
March	17.00	15.50	16.50	14.50	16.50	15.00
April	17.00	15.50	16.50	14.50	16.50	15.00
May	17.00	.....	16.38	.....	16.44	.....
June	17.00	.....	15.50	.....	16.00	.....
July	17.00	.....	15.50	.....	16.00	.....
August	17.00	.....	15.50	.....	16.00	.....
September	17.00	.....	15.50	.....	16.00	.....
October	16.92	.....	15.42	.....	16.00	.....
November	16.50	.....	15.00	.....	16.00	.....
December	16.25	.....	15.00	.....	15.75	.....
Year	16.96	.....	15.88	.....	16.25	.....

Iron in dollars per long ton. [1]F.o.b. Mahoning and Shenango Valley furnaces; freight to Pittsburgh, $1.76.

prices for the Prime Western grade.

Quotations for lead reflect prices obtained for common lead, and do not include grades on which a premium is asked.

London prices for lead and zinc are the official prices for the morning session of the London Metal Exchange; prices for copper and tin are the official closing buyers' prices. All are in pounds sterling per long ton (2,240 lb.).

New York silver quotations are as reported by Handy & Harman and are in cents per troy ounce of silver, 999 fine. London silver quotations are in pence per troy ounce of bar silver, 925 fine. Sterling prices represent forenoon market demand. Cables command a premium.

Mining Share Prices—Month of April, 1932

Company Name	High	Low	Last	§Most Recent Dividend
NEW YORK STOCK EXCHANGE				
Alaska Juneau	16⅛	8.25	8.87½	Ap. 9, My. 1 1932....Q 0.12½
American Metal	4.00	2.37½	2.50	December, 1930....Q 0.25
Am. Metal, pfd.	14½	10	10½	Au. 22, Se. 1, 1931....Q 1.50
Am. Sm. & Ref.	10⅜	7.50	9.50	Ja. 15, Fe. 1, 1932....Q 0.12½
Am. Sm. & Ref. 2d pfd.	35	25	25½	My. 6, Je 1, 1932....Q 1.50
Am.Sm. & Ref. 1st pfd.	55	45	45½	My. 6, Je 1, 1932....Q 1.75
Am. Zinc, L. & S.	2.25	1.50	1.75	May, 1917.... 1.00
Am. Zinc, L. & S., pfd.	19¾	14½	19½	October, 1930....Q 1.50½
Anaconda	6.00	4.50	4.75	Jy. 11, Au. 17, 1931....Q 0.37½
Andes Copper	2.37½	2.00	2.37½	Ja. 10, Fe. 9, 1931....Q 0.25
Butte C. & Z.	0.87½	0.50	0.62½	December, 1929.... 0.50
Butte & Superior	0.75	0.75	0.75	December, 1929....Q 0.50
Callahan Zinc-Lead	0.37½	0.25	0.37½	December, 1920.... 0.50
Cal. & Hecla	2.37½	2.00	2.12½	June, 1930.... 0.50
Cerro de Pasco Copper	7.50	5.50	6.00	Ja. 14, Fe. 1, 1932....Q 0.25
Dome Mines	9.25	8.00	8.75	Je. 30, Jy. 20 ....Qx 0.45
Federal M. & S.	20	20	20	June, 1927.... 10.00
Federal M. & S., pfd.	....	....	36*	My. 25, Je. 5, 1931....Q 1.75
Freeport Texas	16½	14	14½	My. 13, Je. 1, 1932....Q 0.50
Granby Con	4.12½	3.62½	4.00	Ja. 15, Fe. 1, 1932....Q 0.12½
Greene Cananea	8.50	6.50	8.50	July, 1930.... 0.75
Homestake	1.23	1.10½	1.14	Ap. 20, Ap. 25, 1932...M 0.65
Howe Sound	9.00	6.00	6.00	Mh. 31, Ap. 15, 1932.... 0.25
Inspiration	2.12½	2.00	2.12½	July, 1930.... 0.50
International Nickel	7.25	5.37½	5.50	De. 1, De. 31, 1931....Q 0.05
Int. Nickel, pfd.	83¾	73	73	Ap. 2, My. 1, 1932....Q 1.75
Kennecott Copper	8.12½	5.50	6.75	De. 17, Ja. 2, 1932....Q 0.12½
McIntyre Porcupine	15	13¾	13¾	My. 2 Je. 1 1932....Q 0.25
Magma Copper	6.25	4.50	5.00	Mh. 31, Ap. 15, 1932....Q 0.12½
Miami Copper	2.50	2.00	2.25	August, 1930.... 0.375
Mother Lode	0.25	0.25	0.25	June, 1930.... 0.10
National Lead	80½	53½	53½	Mh. 18, Mh. 31, 1932..Q 1.25
National Lead, pfd. A.	1.15	1.00	1.03	My. 27, Je. 15, 1932....Q 1.75
National Lead, pfd. B.	99	85	85	Ap. 22, My. 2, 1932....Q 1.50
Nevada Con.	4.12½	2.75	3.25	De. 17, De. 31, 1931....Q 0.10
Noranda Mines	15¾	13	13	De. 15, De. 29, 1931.... 0.50
Park Utah Con.	1.00	0.62½	0.62½	July, 1929....Q 0.20
Patino M. & E.	5.00	3.25	3.25	December, 1929.... 4s.
Phelps Dodge	6.00	4.00	4.62½	Je. 18, Jy. 1, 1931....Q 0.25
Rand Mines	....	....	20*	August, 1930.... 1.52
St. Joseph Lead	6.75	5.12½	5.62½	Mh. 10, Mh. 21, 1932...Q 0.15
Seneca Copper	0.25	0.25	0.25	....
Tennessee Corp.	1.75	1.12½	1.62½	Fe. 28, Mh. 16, 1931....Q 0.125
Texas Gulf Sulphur	20½	16	18	Mh. 1, Mh. 15, 1932...Q 0.50
U. S. S. R. & M.	15	11½	13½	Ap. 4, Ap. 15, 1932....Q 0.25
U. S. S. R. & M., pfd.	37¾	35	35	Ap. 4, Ap. 15, 1932....Q 0.87½
Utah Copper	36½	36½	36½	De. 17, De. 31, 1931....Q 1.00
Vanadium Corp.	11	7.87½	7.87½	Fe. 2, Fe. 16, 1931....Q 0.75
NEW YORK CURB EXCHANGE				
Aluminum Co. of Am.	31½	24	26	....
Alum. Co. of Am., pfd.	50	35	35½	Ap. 1, 1932....Q 0.75
Anglo-Chilean Con.	0.25	0.25	0.25	4 shares Cosach B...June, 1931
Bunker H. & S.	20½	16	16	De. 31, Ja. 5, 1932....Q 1.50
Carnegie Metals	....	....	1.25*	....
Comstock Tunnel	0.43¾	0.25	0.37½	....
Con. Coppermines	0.75	0.56½	0.62½	....
Copper Range	1.50	1.12½	1.12½	July, 1930.... 0.25
Cresson Consolidated	0.18¾	0.12½	0.18¾	Je. 30, Jy. 10, 1931....Q 0.01
Cusi Mexicana	0.25	0.18¾	0.18¾	....
Evans-Wallower	0.18¾	0.12½	0.18¾	....
Federated Metals	5.50	5.25	5.25	Ja. 5, Ja. 15, 1931....Q 0.25
Hecla Mining	3.00	2.50	2.62½	Fe. 15, Mh. 15, 1932...Q 0.10
Hollinger Consolidated	4.37½	4.12½	4.25	My. 5, My. 19, 1932...M 0.05
Hudson Bay M. & S.	1.75	1.50	1.50	....
Iron Cap Copper	0.56½	0.50	0.50	....
Mayflower Associates	24½	21	21	Mh. 1, Mh. 15, 1932...Q 0.50
Mining Corporation	0.75	0.75	0.75	December, 1929.... 0.12½
New Jersey Zinc	24½	14½	19¾	Ap. 20, My. 10, 1932...Q 0.50
Newmont Mining	9.00	7.50	8.50	Mh. 31, Ap. 15, 1931..Q 1.00
N. Y. & Honduras Ros.	13¾	13	13	Ap. 13, Ap. 23, 1932...Qx 0.50
Nipissing	0.75	0.50	0.75	Mh. 31, Ap. 20, 1931..Q 0.075
Ohio Copper	0.12½	0.06½	0.12½	September, 1926.... 0.03
Premier Gold	0.37½	0.37½	0.37½	Mh. 14, Ap. 4, 1932.... Q0.03
Quincy	1.25	1.12½	1.12½	March, 1920.... 1.00
Shattuck Denn	1.25	1.12½	1.25	....
So. Am. Gold & Plat.	....	....	0.75*	....
Teck-Hughes	4.12½	3.00	3.25	Ap. 15, My. 1, 1932...Q 0.15
Tonopah Mining	0.25	0.25	0.25	October, 1929.... 0.07½
United Eastern	....	....	0.06½*	....
United Verde Ex.	3.00	1.50	2.25	Ap. 2, My. 2, 1932....Q 0.12½
Utah-Apex	0.50	0.50	0.50	December, 1929.... 0.02
Yukon Gold	0.12½	0.12½	0.12½	June, 1918.... 0.02
BOSTON STOCK EXCHANGE				
Isle Royale	1.25	1.00	1.12½	March, 1930.... 0.50
Mohawk Mining	17	14	16½	Ap. 30, My. 31, 1932....Q 0.25
Old Dominion	0.25	0.25	0.25	December, 1918.... 1.00
Utah Met. & Tunnel	0.36	0.30	0.35	December, 1927.... 0.30
¶MONTREAL				
Asbestos Corp.	....	....	0.20*	January, 1926.... 1.50
Asbestos Corp., pfd.	....	....	0.60*	January, 1930.... 1.75
Consolidated M. & S.	0.65	0.35	0.39	De. 23, Ja. 15, 1932.SAX 1.25

Company Name	High	Low	Last	§Most Recent Dividend
SPOKANE				
Constitution	....	....	0.06¾*	....
Dayrock	....	....	0.95*	March, 1930.... 0.03
Golconda	0.16½	0.16½	0.16½	July, 1929.... 0 02
Jack Waite Con.	0.12½	0.07½	0.08½	....
Los Lugos	....	....	0.01½	....
Mexican Premier	0.04	0.02½	0.03	January, 1930.... 0.01
Montana Mines	....	....	0.09*	....
Noble Five	....	....	0.03*	January, 1930.... 0.005
Pend Oreille	0.55	0.55	0.55	....
Sherman Lead	....	....	0.25*	March, 1930.... 0.01
Sidney	....	....	0.05*	October, 1929.... 0.01
Sunshine Mining	1.13	1.04	1.06	Mh. 10, Mh. 21, 1932.... 0.02
Tamarack & Custer	....	....	0.13¾*	September, 1924.... 0.25
SALT LAKE CITY				
Chief Con.	26	25	26	February, 1928.... 0.10
Combined Metals	4.50	4.00	4.50	....
Eureka Bullion	6.50	6.00	6.25	....
Eureka Lilly	6.00	5.50	6.00	....
Moscow Silver	30	25	25	....
New Quincy	1.50	1.00	1.00	September, 1929....Q 0.10
North Lily	35	32	32	January, 1930.... 0.15
Park Bingham	1.25	0.75	0.75	....
Park City Con.	10½	9.50	9.50	....
Rico Argentine	2.75	2.25	2.25	December, 1929.... 0.03
Silver King Coalition	2.75	1.90	2.10	De. 20, Ja. 2, 1931....Q 0.15
Tintic Lead	95	90	90	....
Tintic Standard	2.25	2.02½	2.12½	Mh. 7, Mh. 31 1932.... Q0.05
Walker Mining	50	38	42	April, 1930.... 0.075
¶ TORONTO				
Abana Mines	0.05½	0.04½	0.04½	....
Amulet Mines	0.15	0.08	0.11	....
Barry-Hollinger	0.07½	0.05	0.06½	....
Base Metals	0.50	0.50	0.50	....
Canam Metals	0.02	0.02	0.02	....
Castle-Trethewey	0.13½	0.12	0.12	....
Central Manitoba	0.06	0.05½	0.05½	....
Falconbridge	0.85	0.60	0.70	....
Granada Gold	1.05	0.75	0.77	....
Howey Mines	0.32½	0.27½	0.28	....
Keeley	0.23	0.20	0.21	March, 1928.... 0.04
Kirkland Lake	0.44	0.30	0.34	....
Lake Shore	29.00	25.90	26.00	Mh. 1, Mh. 15, 1932...Q 0.50
Sherritt Gordon	0.45	0.30	0.31	....
Siscoe Gold	0.66	0.56	0.59½	Mh. 21, Mh. 31, 1932...I 0.04
Sylvanite	0.52	0.42	0.46	De. 5, De. 31, 1931...SA 0.02
Treadwell Yukon	3.00	1.70	1.75	....
Ventures	0.43	0.22	0.24	....
Vipond Con.	0.35	0.27	0.28	April, 1927.... 0.03
Waite-A.-M.	0.60	0.27	0.27½	....
Wright-Hargreaves	2.65	2.22	2.30	Mh. 10, Ap. 1, 1932....Q 0.02½
ST. LOUIS, CINCINNATI, AND DENVER				
Consolidated L. & Z.	0.50	0.50	0.50	December, 1929.... 0.125
Eagle-Picher	3.75	3.50	3.50	April, 1930.... 0.20
Eagle-Picher, pfd.	....	....	89*	De. 31, Ja. 15, 1931....Q 1.50
Empire Chief	....	0.00½	(a)	....
Star of Utah	0.08	0.01	(a)	....
Tungsten Prod.	0.06	0.02	(a)	....
Ute Gold	0.06	0.04	(a)	....
SAN FRANCISCO, LOS ANGELES, AND COLORADO SPRINGS				
California Copper	0.37½	0.12½	0.37½	....
(a) Golden Cycle	10.50	9.50	9.75	Fe. 29, Mh. 10, 1932...Q 0.40
(a) Granite Gold	0.16	0.10	0.15	Mh. 23, Ap. 2, 1932....Q 0.01
Idaho-Maryland	2.02	1.84	1.95	....
Tom Reed	0.20½	0.15½	0.18	De. 15, Ja. 1, 1932....Q 0.03
(a) United Gold	0.06	0.03¾	0.05	Oct. 15, No. 1, 1931....0.01

‡LONDON

Company Name	High	Low	Last	Most Recent Dividend (Per Cent, Unless Noted)
Anglo American	7/–	4/6	5/7½	22½, Feb. 19, 1930
Aramayo Mines	12/6	6/3	8/9	5, Oct. 23, 1929
Burma Corporation	8/10½	7/4½	7/10½	1¼, Dec. 10, 1930(b)
Camp Bird	–/6	–/1½	–/3	16¾, April 25, 1928
Fresnillo	6/3	6/3	6/3	25 cents, Feb. 12, 1930
Frontino & Bolivia	16/9	15/10½	16/9	2½, July 1, 1931
Lake View & Star	10/3	9/–	9/9	11½, 1921
Mexican Corporation	2/6	2/6	2/6	10, Oct. 24, 1929
Oroville Dredging	6/7½	5/–	6/3	37½, May 16, 1930
Rhodes.-Select. Trust	62/6	47/6	60/–	....
Rhokana Corp.	5/7½	4/7½	5/3	....
Rio Tinto	14½	11	13½	Ap. 29, My. 9, 1932....2s. 6d.
St. John del Rey	19/–	17/4½	18/9	9d, No. 20, 1931
San Francisco Mines	8/7½	5/9	6/–	10, Jan. 7, 1931
Santa Gertrudis	6/–	4/7½	4/9	9d., July 9, 1931
Selukwe	1/7½	1/4½	1/6	6¼, April 2, 1917
So. American Copper	–/6	–/4½	–/4½	....
Tanganyika	19/3	14/6	15/7½	2½, Aug. 2, 1930
Wiluna Gold	19/4½	14/3	18/9	....
Union Minière	3,655	3,075	3,075	240 francs, July, 1931

Salt Lake Stock Exchange courtesy J. A. Hogle & Company. ¶These figures are quoted in Canadian dollars. *Not traded in. †Belgian francs. ‡The above London quotations are for the month ended Feb. 23. Q, quarterly; I, initial; M, monthly; X, extra; SA, semi-annual; L, liquidating B, plus bonus. §Total dividends paid during the month will be found tabulated in the Market and Financial News Section. Dates here given are those of closing of books and payment of dividend. (a) Bid prices. (b) 1¼% (2 annas) dividend, and bonus of ¼% (1 anna). (c) Closing bid prices. F.W., four weeks.